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Forthcoming Events.

APRIL 3.

Institution of Mining and Metallurgy:—Annual dinner in London.

Birmingham Metallurgical Society:—Ordinary meeting at Birmingham. "Electric Furnaces," Paper by A. G. Lobley, M.Sc.

Birmingham Metallurgical Society:—Ordinary meeting at Birmingham. "Electrical Annealing," Paper by J. H. Crossley, B.Sc., Wh. Ex.

APRIL 4.

West of Scotland Iron and Steel Institute:—Annual general meeting at Glasgow.

Institution of Mechanical Engineers:—Ordinary meeting at Leeds. "Design and Manufacture of Steel Castings," Paper by F. Darley.

APRIL 8.

West Yorkshire Metallurgical Society:—Ordinary meeting at Huddersfield. Discussion on "Engineering and Metallurgical Specifications."

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

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June.

For British foundry interests, June promises to be an exceptionally busy month. Primarily, on June 4, 5 and 6, there is the Newcastle Convention of the Institute of British Foundrymen, the arrangements for which are now almost completed. Later in the month, June 19 to June 28, the International Foundry Trades' Exhibition takes place at the Bingley Hall, Birmingham. Concurrently with the Newcastle Convention, a mining and metallurgical conference is to be held at the British Empire Exhibition at Wembley. The outstanding events for foundrymen are obviously the Newcastle Convention and the Foundry Exhibition. The arrangements for the Convention are to follow the usual lines, but on a more elaborate scale than is customary. Already numerous large engineering and other industrial establishments have promised to throw open their shops for inspection. The Lord Mayor is giving a garden party, seats are already taken in the theatres, hotel reservation has been made, and the list of papers to be presented has almost been completed. The subjects to be dealt with will include foundry procedure in the United States and Holland; oil sand cores; different forms of graphite in cast iron; and non-ferrous foundry practice. Newcastle hotel accommodation is limited, and intending participants would be well advised to make reservation as soon as possible. Foundrymen, who are not members of the Institute of British Foundrymen and who wish to take part in the Conference, should apply to the nearest branch secretary, whose addresses are given in the adjoining column, for particulars of membership and qualifications necessary. The Newcastle Reception Committee specially desire that intention to participate should be notified as early as possible to their honorary secretary, Mr. Colin Gresty. A record gathering of foundrymen is confidently expected.

The Foundry Exhibition is to follow similar lines to that held in 1922. Lord Weir is to be president and Mr. Oliver Stubbs, president of the Institute of British Foundrymen, chairman of the Executive Committee of the British Cast Iron Research Association, and chairman of the National Ironfounders' Federation, heads the list of vice-presidents. A strong technical advisory committee has been formed, and they will arrange patternmaking and moulding competitions, a series of technical lectures, and take care of the scientific and historical exhibits. It is not proposed to include a model foundry this year, as it is felt that it is impossible to do justice to such a feature in the space available. The absence of this exhibit will allow more space to be devoted to the competitions. A number of important Colonial and foreign foundrymen have already promised to be present, and, no doubt, Wembley will be the contributory cause of the presence of many others. Inquiries for space have exceeded all expectations, and firms who do not decide reasonably quickly may be crowded out. Most of the prominent foundry equipment manufacturers have arranged to be represented, and the making of moulds by hydraulic ramming, jar ramming, pressure squeezing and sand-slinging is to be demonstrated. THE FOUNDRY TRADE JOURNAL will again occupy the central position in the Hall. Foundries should arrange as soon as possible to be represented at both the Newcastle Convention and the International Exhibition, for the former represents the germination and dissemination of ideas for the improvement of foundry practice and the latter their translation into practice.

Institute of British Foundrymen.

Convention Fund.

In connection with the Fund for the Annual Convention of the Institute of British Foundrymen, which is to be held in Newcastle during the first week in June, the Hon. Treasurer (Mr. H. F. Parsons) announces a further list of subscriptions as follows :—

Previously acknowledged, £415 12s.; Sir W. G. Armstrong, Whitworth & Company, Limited, £25; the Darlington Railway Plant & Foundry Company, Limited, £20; Parsons Marine Steam Turbine Company, Limited, Wallsend, £10; Mr. Oliver Stubbs, Manchester, £5 5s.; Messrs. Hall & Pickles, Limited, £5 5s.; Messrs. Donkin & Company, Limited, £5 5s. Junion Section, Newcastle Branch, £4 4s. 6d.; Messrs. John Wigham & Sons, Limited, Sunderland, £3 3s.; Messrs. John Saunders, Limited, Sunderland, £3 3s.; the British Associated Machine Tool Makers, Limited, £3 3s.; Mr. Geo. Vardy, £3 3s.; Messrs. Lingford, Gardiner & Company, Limited, Bishop Auckland, £2 2s.; Mr. A. Wimble, £2 2s.; Mr. J. H. Watson, £2 2s.; Mr. W. J. Paulin, £2 2s.; Messrs. C. H. Tate & Son, £2 2s.; Mr. W. P. Harrison (Chas. Churchill & Company), £2 2s.; the South Durham Steel & Iron Company, Limited, Stockton, £2 2s.; Messrs. W. & T. Avery, Limited, £2 2s.; Messrs. T. Herbert Wait & Company, £2 2s.; the Tyne Iron Shipbuilding Company, Limited, £2 2s.; Mr. J. P. Hall, £2 2s.; Messrs. W. Parry & Son, South Shields, £2 2s.; Messrs. Jas. Durrans & Sons, Limited, Sheffield, £2 2s.; Messrs. Jackson & Brother, Limited, Bolton, £2.

Messrs. L. S. Carr & Company, £1 1s.; Mr. Russell Jackson, £1 1s.; Mr. J. A. Campbell, £1 1s.; Messrs. Wasteneys Smith & Sons, £1 1s.; Messrs. Alfred Herbert, Limited, £1 1s.; Mr. A. Stothard, £1 1s.; Mr. T. McPherson, £1 1s.; Mr. C. W. Bryant, £1 1s.; Mr. C. W. Hutchinson, £1 1s.

Mr. R. Stobbs, £1; Moulders & Core-Makers, the North-Eastern Marine Engineering Company's Sunderland Foundry, 17s.; Brassfounders, the North-Eastern Marine Engineering Company's Wallsend Foundry, 14s.; Messrs. Snowdon & Blackwood, South Shields, 10s. 6d.; Mr. F. P. Wilson, 10s. 6d.; Mr. E. H. Wainford, 10s. 6d.; Mr. F. Hudson, 10s.; Mr. P. McLaughlin, 5s.; total, £546 16s.

The Hon. Treasurer, Mr. H. F. Parsons, 8, Heaton Park View, Heaton, will be pleased to receive further subscriptions, which will be acknowledged through the Press.

Foundry Queries.

Locomotive Cylinder Mixtures.

We would refer "Cylinders" to the recent correspondence which has been running through the Journal under the caption of "The Decline of Semi-Steel." The general concensus of opinion was that semi-steel cast iron is on the wane because trade conditions have been such that good runs on jobs requiring this material could not be obtained, and further, the difference in price of suitable steel scrap and suitable pig-iron had been narrowed. Well-made semi-steel cast iron is quite suitable for locomotive cylinders, and we would advise "Cylinders" to submit two castings, one of semi-steel cast iron and the other of a normal pig-iron base, and ask the objecting railway company to say which was which, and to state their preference. There should be no difficulty in meeting the tests specified.

Additional offers of help have been received from Major Tavenor, of Abbey House, Victoria Street, Westminster, S.W.1, and Mr. H. G. Sommerfield, of Charterhouse Chambers, Charterhouse Square, London, E.C.

Core-Ramming Machines.

If J. W. and C. J. P., Limited, will provide a sketch, we believe it would be possible to utilise several existing types of core-ramming machines.

Tuyere Areas.

Are three tuyeres of 3-in. dia. suitable for a cupola of 2 ft. 6 in. dia. If not, what number and size of tuyeres ought to be used?—B.F.

British Pig-irons, Limited, Abbey House, 2, 4, 6 and 8, Victoria Street, Westminster, London, S.W.1, announce that the nominal capital of the company has now been increased to £10,000

The Ryarsh Sand Company, Limited, have removed their registered office from 1, Queen Anne's Gate, Westminster, S.W.1, to Ryarsh, West Malling, Kent. The telephone number is Malling 63. Mr. Rex Lambert has been appointed manager.

Safety Goggles.

On many occasions we have referred to the lack of thought put into the various types of eye protectors associated with foundry practice. Primarily, many fettlers require plain eye goggles; men handling liquid metal should have tinted ones; steel melters, blue ones; and electric furnacemen goggles capable of reducing light intensity and cutting out the actinic rays—ultra-violet and infra-red.

The firm of Messrs. S. Pulzer, 45, Hatton Garden, London, E.C.1, have secured the sole agency for the Willson goggle, and have developed a service capable of taking care of the whole of the peculiar requirements of the foundry industry.

For fettling, they have a laminated glass carried in a ventilated eye cup, finished black to prevent glare, and provided with a safety flange to afford maximum protection in case of breakage. The leather bridge and elastic head band are adjustable. A modified type which replaces the perforated eye cup by a capped port hole has been specially designed to prevent dust from entering the eye. Another modification provides a goggle which can be worn over ordinary eye-glasses.

For cupola work or handling hot metal, a series of coloured goggles are made. They carry leather side shield in place of the metal eye cups. Some are just smoked glass, others cobalt blue, others bicoloured.

For steel melting the goggles have wire screen side shields, and all the parts touching the face are edged with velvet.

We presume that the goggle for electric furnace melting is that advocated for heavy welding. A glass bearing the trade name "Industro" is being made in four shades, which are designed to arrest actinic rays. If the dual problem of cutting down intense glare and arresting dangerous rays has been solved, then the Willson goggle will be welcomed by those in charge of the hundred or more electric furnaces in Great Britain. Mechanically, the glasses are definitely sound.

A boon to smelters is shown by the Willson anti-sweat pencil, for which the manufacturers claim that application on both sides of the glass, after polishing, will permit of clear vision for several hours.

Welding helmets and hand shields are other safety-first apparatus handled by this firm.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

To the Editor of the Foundry Trade Journal.

"New Era in Foundry Research."

Sir,—Your leader in this week's Journal should receive the careful consideration of all foundry owners and workers, for it deals with a subject of vital importance to the foundry industry.

Particularly in the preparation and testing of moulding sand is it desirable that some satisfactory and simple tests should be standardised and specified for general use, so that future results may be directly comparable with each other. At the present time each worker in this field has his own particular methods of testing which are apt to be confusing to those who are interested. It is also desirable that a greater spirit of co-operation should be developed between the metallurgist and the foundryman; that the metallurgist should endeavour to see things from the foundryman's point of view, and that the foundryman should be willing to consult with the metallurgist in order that each may give of his best and so produce the desired result.

This is coming gradually, and when it does arrive then the new era in foundry research will be well established.—Yours, etc.,

Ernest Wheeler.

Manchester,
March 29, 1924.

Mr. George Hall, a member of the Council of the London Branch of the Institute of British Foundrymen, has formed a partnership with Mr. Robert Figg, and will trade as Figg & Company, at Bridge House, 181, Queen Victoria Street, London, E.C.4. The firm intends to carry on business as general engineering merchants and agents, ironfounders, etc.

Malleable Iron Chain.*

By J. W. Gardom, M.I.Brit.F.

The subject of this Paper was selected because it was thought that the manufacture of a product which lends itself—and is—manufactured on repetition lines would be of interest to foundrymen at the present time. Further, a description of manufacturing methods of a particular article enables more constructive criticism being offered than when general principles are involved.

The iron used in making this chain is the European or white-heart malleable, as this, when correctly made, is more suitable for chain than the black-heart iron.

Various types of malleable chain are produced, such as Ewarts, Pintle and Grays type. Each style has a large number of sizes, and each size a larger number of different attachment links. This involves a great number of costly patterns.

It is intended to deal more particularly with Ewart's or detachable-type chain, although the manufacturing principle is similar for the various classes.

When making forged chain and cast-steel chain, the links are joined together in the process of manufacture, whilst in some cases individual links are made, then spaced a link apart in a long mould, and the intermediate links cast through them. In all such cases the complete chain is the problem of manufacture.

In detachable chain the production of accurate individual links is the problem. The moulder may never see the completed chain.

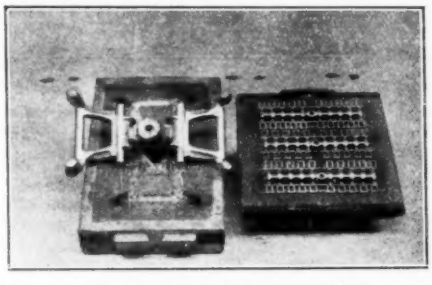

Fig. 1.—Patterns for Malleable Chain are Made Up in Sprays from Two to Sixty Links.

The preparation of the patterns is specialised work, while particular care is necessary in running and feeding the links to ensure perfect soundness, and to counteract the high contraction in malleable of ¼ in. to the foot.

The patterns (Fig. 1) are made up in sprays of from two to sixty links, dependent upon size, with an odd side of plaster, traverse or metal. So far, it has not been possible to use match-plate patterns for this work.

Foundry.

For moulding, a hand-squeezer portable machine is used, as is shown in Fig. 3.

The operation of making a mould on this machine is as follows: First, the odd side with pattern and bottom box is placed in the centre of the table, and is riddled on and the box is shovel-filled with sand. Using the shovel handle, the mould rams round the sides of the box. The mould is struck off level and the bottom board is placed in position. The presser top is pulled forward with the left hand, and with the right hand the lever on the right of the machine is pressed on. The box is rolled over and the odd side is replaced by the top box, and the above operations are repeated, but the presser board is used, which has knobs fastened to it to mark the position of feeders and pouring gates instead of the bottom board. The presser top is pushed back, the gate and feeders cut through, and the pattern tapped *across* the links, so that no alteration of the length takes place, which would destroy the pitch.

The mould is then opened, the pattern is withdrawn, and the cores placed in position. The top is replaced, the snap box opened and put on one side, and the mould placed on the floor in a position for casting.

The moulding operations have been given in detail because it is proposed to outline some figures of the output obtained. These figures represent work repeated daily, and are given by a user to help foundry managers in selecting a moulding machine for their requirements. It must be remembered that different jobs require different moulding machines, a point often forgotten, it being quite usual, when a change is made from floor to machine moulding, to expect the one type of machine bought to do all the various work of a jobbing foundry.

The usual method of giving the number of moulds turned out by a machine per day is not satisfactory, because no comparison can be made of the labour cost of working the machine. It is proposed, therefore, to give the output as moulds per man per hour. This has been obtained by dividing the number of moulds put down from 50 machines by the number of men employed to turn out the castings from these, and includes the labour engaged in sand preparation, moulding, casting, cupola operation, and the necessary general labour, cleaning up, etc. If this method

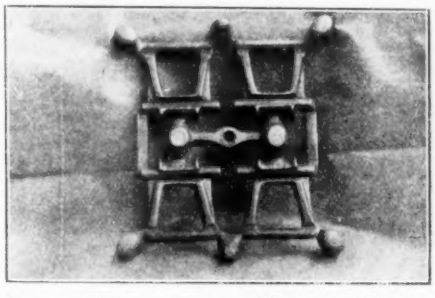

Fig. 2.—Illustrating the Method of Running Links.

was always used, a more correct figure for comparing one type of machine with another would be obtained.

The figures given in Table I are a daily average.

Table I.—*Output from Machine Mould Chains.*

Size of box.	Chain.	Moulds per box Cores	Moulds per hr. per man
14 × 14 × 3 × 3 in.	1-in. pitch	60	7
18 × 10 × 3 × 3 in.	1½-in. pitch	24	8

When it is remembered that in some cases a man is laying as many as 4,000 cores a day, it is thought that the Bagshawe concern can feel proud of this output. To obtain this it is essential that every help, such as perfect patterns and boxes and easily-riddled sand, must be given to the moulder, and everything possible standardised.

To give a general comparison in this foundry when this type of machine is used, an output of 120 moulds per machine is obtained in eight hours for a 14 × 14 × 3 × 3-in. mould with no cores.

To relieve monotony, each moulder "turns over" his own sand, brings the necessary facing sand from the mill, brings his cores from the core room, casts and knocks out his own work.

By this method a greater output per man is obtained than if monotony is allowed to affect the work by keeping a man at one particular job.

The cores used are made up from half red moulding sand and half burnt sand, to which is added various small proportions of resin. These are made up in banging boxes, one girl turning out 4,000 cores for 1-in. pitch chain per day.

All the work is cast from hand ladles, which

* Paper presented to the London Branch of the Institute of British Foundrymen, Mr. V. C. Faulkner presiding.

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are filled direct from the cupola. It is usual to obtain the stream of iron from the cupola at such a speed that no "bottling up" is necessary during the whole of the cast.

As soon as the castings are set, they are "knocked out" of the moulds. At the end of the cast the feeders and runners are "knocked off" and the links passed to the cleaning department.

After cleaning, each link is subjected to a double inspection, where all defective moulding or links likely to give trouble in too-tight or too-loose fitting are rejected.

Annealing.

After inspection, the work is passed to the annealing department. The links are placed in iron boxes 2 ft. 6 in. × 2 ft. × 1 ft., and surrounded by ore. This packing must be carefully carried out, so that distortion of the links is avoided during the heat treatment. Six boxes are placed one upon the other to form a tier, which is then conveyed into the annealing oven; when the ovens are full, the doors are closed, luted up and firing commenced. After about 48 hours' firing, full heat temperature of about 900 deg. C. is reached. The oven is then held at this temperature for a definite period, then closed down, and the temperature allowed to fall to 750 deg. C. in a given time. The furnace is then again taken up to full heat, and the process of holding at heat and closing down is repeated. The number of hours the furnace is held at full heat in each high-temperature period, and the number of times the temperature is allowed to fall, is dependent upon the chemical composition of the iron, the ore strength, and the thickness of the work to be

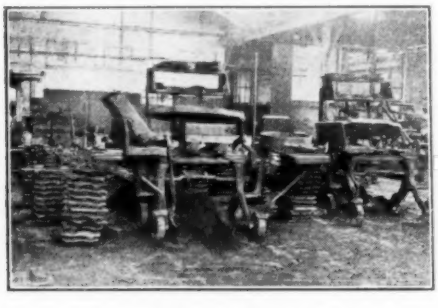

Fig. 3.—Hand Squeezer Portable Moulding Machines are Used.

annealed. After the necessary annealing time the furnace is allowed to fall to below 600 deg. C., when the tiers of pans are withdrawn and the castings dumped on to grids. After being rumbled they are subjected to a second inspection and passed into the grinding department, where the runners are ground off. Most of the links being run on the hook, it is necessary to use great care in grinding, so that the correct form of the hook is not destroyed, this coming into mesh with the teeth of the sprocket wheel when the chain is in use (Fig. 6).

Assembling the chain is perhaps the most interesting part of the manufacture, and the cost of the operation is not high, owing to the ease with which the links can be put together. Care, however, must be taken that the fit is not so loose that the links will come apart in handling. A "nip" is placed in the side arms close to the tail bar. This allows one link to slip into another when the links are held at an angle of 60 to 70 degrees one with the other. Each link is taken from a stock pile placed at the proper angle, with respect to the last link, pressed into position, and then straightened (Fig. 7).

The links are made up into 10-ft. coils, each coil being tested against a standard to check the pitch.

The allowable variation of a 10-ft. coil being plus or minus ½ in., each coil is now subject on a special test machine to a combined tensile and shock test of double the working strain. The coils are again checked for pitch against a standard and, if correct, are passed into stores.

Metallurgy of Chain Making.

Turning now to the metallurgical side of the production of malleable iron chain, it is intended to go through each stage of the production, pointing out the theoretical side of the process, but more particularly to lay stress upon the application of the theory to the practice. The iron, as cast, has a chemical composition of approximately:—T.C., 3.2; Si, 0.6; S., 0.25; P., 0.1; and Mn, 0.13 per cent. Each constituent must be kept within very close limits of these figures, and such an iron, when broken, must give a white fracture, and when examined microscopically, must show pearlite, as a dark constituent, and white cementite. To produce such an iron in the cupola is difficult. It must be remembered that the work to be cast is very small, so that a very hot iron is required. The usual method obtaining hot iron is to increase the coke to iron melting ratio, but this would mean increased carbon absorption by the molten metal, and as any increase in T.C. is a disadvantage, very close watch must be kept upon the coke charges and the air supply. The desired result is best obtained by using a very soft blast and melting somewhat on the slow side, this method of melting also helping to reduce the possibility of over-oxidation of the metal, which with such a low silicon content is liable. It has been stated by Mons. T. Levoz, "Fonderie Moderne," June, 1922, that oxidation of the iron during melting is the cause of most failures in malleable iron production.

Further, it is necessary that the composition of the iron should not vary at any part of the cast. To obtain this result, various methods have been tried, such as a receiver in front of the cupola, a double tap-hole, one above the other, so that a quantity of iron is held in the crucible of the cupola. Both these methods tend to cool the

Fig. 4.—The Annealing Ovens.

iron, so that to work them successfully a high melting temperature must be used, with its consequent detrimental increase in carbon absorption. They have therefore been discarded, and advantage is taken of the practically demonstrated fact that the charges in the cupola cannot be definitely separated. It is well known that the increase in sulphur and loss of silicon is greater at the beginning of a cast than at the end. The charges are therefore made up accordingly, *i.e.*, with a decreasing silicon content from the first to the last charge, and an increasing sulphur content.

As more than one charge is in the melting zone at a time, a practically constant chemical composition is obtained. This is checked by having an analysis from a test-bar cast every 1 ton of metal melted. The moulds are knocked out as soon as the castings are solid; this is an aid to the retarding of graphite formation, as it is well established that slow-cooling of iron produces large graphite flakes. Any particles of graphite present in the "as cast" material limit the possibility of obtaining good bending properties after annealing.

Annealing.

While it is perfectly true to state that, unless the castings received from the foundry are of the correct chemical and microscopical composition, no amount of annealing will produce malleable iron, 90 per cent. of the defective malleable produced is due to incorrect annealing.

Pyrometers.

Pyrometers are used to control the heat treatment. It is certainly surprising to hear men in

charge of heat-treatment work say that pyrometers are useless, particularly when in some cases these men have actually worked with pyrometers. No heat treatment can be constantly repeated successfully without the use of some mechanical check upon the temperatures. The present-day pyrometer is quite a robust instrument, and with ordinary care and a little understanding will give years of service.

In using a pyrometer, the main point to be remembered is that the temperature reading shown upon the indicator is only the temperature of the furnace at the particular point where the couple is inserted. In a large room it is obvious that a thermometer placed in the draft from a window or doorway could not give the correct temperature of the room, yet that is so often exactly what a pyrometer is expected to do. Couples are often seen so placed in a furnace that the flame from the heating source plays around them. The correct position of a pyrometer is for the hot junction of the couple to be in contact with the work. That is, for the present conditions, it should be buried into the centre of a row. This is not practical, because of the excessive length of couple that would be required, and also the number of breakages due to the rows settling down during the heat treatment.

To overcome this difficulty it was necessary so to place the pyrometer that its reading would give a similar figure to that obtaining if the couple had been placed in the centre of the row. This condition was obtained by placing one couple in contact with the work and another couple through the furnace wall with firebrick insulation around the hot junction. The thickness of this insulation was varied until a definite ratio was obtained

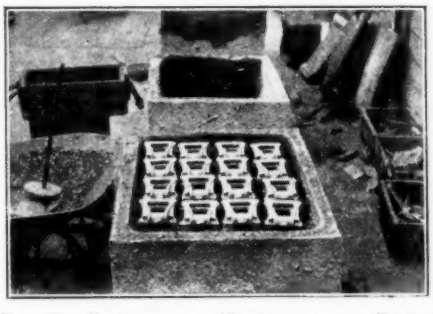

Fig. 5.—Showing the Packing of the Boxes.

between the thickness of firebrick and depth of ore and work, to give a similar heat penetration.

Ore.

The work is packed in hematite ore, a proportion of new ore being used with a proportion of old ore. The physical advantage of this packing is to prevent undue distortion of the castings during the annealing process. Its chemical action is that the ferric oxide of the ore splits up when heated, giving off oxygen gas, which directly or indirectly combines with the carbon of the casting. There can be no doubt that the ferric oxide present in the ore is the essential constituent governing the annealing process, although it has been shown that such impurities as oxides of calcium and manganese must be kept within certain limits. As, however, different brands of annealing ore vary in their ferric oxide content from as low as 75 per cent. to as high as 97 per cent., it is surprising that the strength of annealing ore to be used is spoken of as one of new to six of old, or as adding sufficient new ore to replace that lost in use. The author has advanced a stage further in his work to the following figures:—For work of less than ¼-in. dia., the ore mixture contains 4 per cent. of ferric oxide; from ¼-in. to ½-in. dia., 7 per cent.; from ½-in. to 1-in. dia., 10 per cent.; and above 1-in. dia, 15 per cent.

Close watch is kept upon impurities and also upon the silica content, which is very important. It is to keep the silica content to the desired ratio that the ore is sieved after each heat treatment.

To confer upon the brittle "as cast" white iron, the desirable malleable quality chemical and microscopical changes must take place. Only one chemical constituent is appreciably altered; this is the carbon, which is greatly lowered, the amount depending upon the time of annealing and the percentage of the other constituents present. An annealed link under the conditions outlined would have about 1 per cent. T.C. Microscopically, the hard cementite, with the elimination of carbon, is broken down into pearlite, with more or less ferrite depending upon the extent of annealing

The ease with which this breakdown of cementite and the elimination of carbon takes place is dependent upon the amounts of the other constituents present, particularly silicon and sulphur. Also the temperature of the anneal, the time at annealing temperature, and the strength of the ore. That carbon is burnt out during annealing there can be no doubt, as this is clearly shown by a simple chemical analysis, as well as by microscopic examination. The actual means, however, by which the oxygen and carbon combine have not yet been proved. The first action must necessarily be the breakdown of the cementite. This is followed by the elimination of carbon by oxidation. It is probable that this combination of carbon and oxygen is a secondary reaction. Does the active gas actually penetrate into the casting, combine with the carbon, and then pass out again into the atmosphere, or does this action only take place on the surface of the casting?

A study of Papers on "Malleable" before the Institute of British Foundrymen, and the discussions by members upon these Papers, seem to show that the penetration of the gas into the casting is generally accepted. With this theory, however, the author cannot agree. He believes

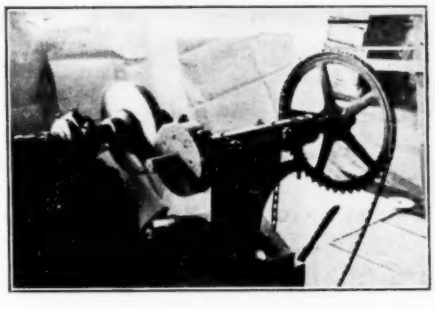

Fig. 6.—The Grinding of the Links.

that oxidation of the carbon by the active gas can, under normal conditions, only take place on the surface of the casting. This being the case, then the elimination of carbon from the centre of the casting can only take place by migration of carbon from the inside to the surface of the casting, where it will then come into contact with the active gas and be oxidised away. This can perhaps be better illustrated by Fig. 8.

Supposing this figure represents a section of a hard, white casting. The percentage of carbon present throughout the section will be constant if taken at varying depths represented by the lines A, B, C, D, E and F. Now surround this section by active gas at a suitable temperature, and the carbon at the surface will combine with the gas and be oxidised. Further oxidation cannot take place until the lowered carbon content at A has been restored by migration of carbon molecules from a point within the section, say B, which in turn receives carbon from points nearer the centre of the section until F is reached. If this theory is correct, then decarbonisation can only take place at a rate dependent upon the speed at which the carbon molecules will migrate to the surface.

Experimental Work.

During the past twelve months the Bagshawe Company has, in its laboratory, carried out numerous tests to prove this theory. The methods used have been partially to anneal test-bars obtaining an exterior low in carbon and the interior with a high-carbon content. These bars were then packed in inert material and heated to various temperatures for varying periods. The work is not yet complete, but the results tend to show that not

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only does this migration of carbon take place, but that varying percentages of chemical constituents present in malleable have an influence upon the migration speed of the carbon.

From research work and practical experience it is known that decarbonisation of the iron cannot take place until a temperature of about 900 deg. C. has been reached. It is, however, a well-established metallurgical fact that diffusion of carbon can take place well below this temperature, but more readily at any point above which the carbon exists as solid solution. Reference to the iron-carbon constitutional diagram will show that this point may be as low as 710 deg. C. It is seen, therefore, that there is a critical temperature below which decarbonisation cannot take place: this is in the neighbourhood of 900 deg. C., and a definite temperature above which diffusion of carbon can take place more or less rapidly: this for malleable iron is about 750 deg. C.

Suppose, then, the work packed in annealing ore is brought up to annealing temperature and held at that temperature for a definite period. The carbon of the surface will be oxidised away, and no further decarbonisation can take place until the deficit has been replaced by diffusion of carbon from the interior.

Diffusion.

As, however, this diffusion can take place rapidly below the decarbonisation temperature, it is perfectly reasonable to allow the furnace temperature to drop below the critical decarbonisation temperature, and as long as the drop is not below the point at which diffusion is rapidly retarded, then annealing (from the essential elimination of carbon point of view) is virtually still taking place. This is the explanation of the "close down" periods during the annealing cycle.

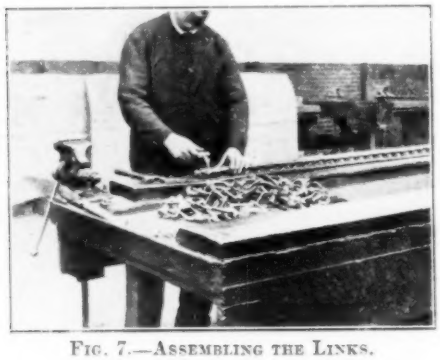

Fig. 7.—Assembling the Links.

Defects due to incorrect annealing are many, but the greatest is that known as skinning. This is shown on bending the work by the outer skin of the casting separating from the core. In its worst form the centre of a bar can actually be withdrawn, leaving an exterior tube. The cause of this has, at different times, been put down to:—(1) Too rapid heating-up of the furnaces; (2) a too high sulphur content; (3) the use of a too high temperature; (4) a too high manganese content; and (5) too strong ore. These factors can all be brought under one definition if one says skinning takes place "when the rate of carbon diffusion from the interior to the surface is less than the rate of carbon elimination at the surface by oxidation. It has been stated that the periods at full heat vary according to the section of the work to be annealed—compare the ratio of the surface of a section to the sectional area of different diameter bars, and the explanation is seen (in Table II):—

Table II.—*Showing the Ratio of Circumference to Area.*

Dia. of Bar.	Circumference.	Area.	Ratio of circumference to Area.
¼ in.	0.785	0.0491	16 to 1
½ in.	1.507	0.1963	8 to 1
1 in.	3.141	0.7854	4 to 1

As the source of supply of carbon to that eliminated on the surface is so much greater in the 1-in. bar to the ¼-in. bar, it is possible to keep larger section work at the decarbonising temperature longer before the first close-down than light section work.

It must be remembered that diffusion of carbon takes place more rapidly the higher the temperature, and as it is necessary, for commercial reasons, to cut the length of time in the annealing ovens to the minimum, the longer the periods at the high temperature, the quicker the elimination of carbon, and consequently the annealing.

Each 10-ft. coil, when tested against a standard for pitch, is only allowed a variation of plus or minus ½ in. in 10 ft. After all the known mechanical errors had been eliminated, it was still found that the pitch of the chain varied from one batch to the next. Experimental work was started to find the cause of this. Keeps' 12-in. bars were used; these were measured after casting and after various heat treatments.

The bars were cast direct from the furnace on different days and at different times, and annealed in the usual way. In the first fifty bars examined the following variations during anneal are shown in Table III:—

Table III.—*Influence of Annealing on Length.*

Lab. No.	Length. as Cast.	Length. after Anneal.	Difference.	Bend.
366	11.866	11.808	— .058 in.	45°
492	11.865	11.858	— .007 in.	90°
507	11.868	11.868	+ .000 in.	70°
560	11.870	11.880	+ .010 in.	73°
570	11.875	11.950	+ .075 in.	45°

By a gradual elimination of varying factors it can now be definitely stated, from the study of some 600 tests in this series, that if all other conditions are identical, then a small variation of the silicon content is sufficient completely to alter the pitch of the chains. The deciding factor appears to depend upon how the iron carbide is split up in the first instance. If temper carbon is deposited a growth is obtained. If decarbonisation takes place at the moment of the cementite breakdown, then a contraction takes place. This is actually the difference between black-heart and white-heart malleable. Of the usual constituents present in malleable, the T.C., Si, S, and Mn can each influence the way in which the cementite is broken down, and so can alter the pitch of the chain.

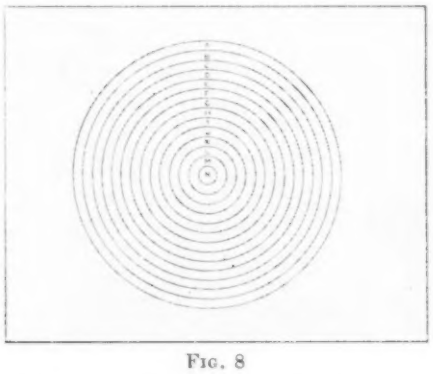

Fig. 8

Test-bars were prepared with a standard analysis of T.C. 3.4, sulphur 0.28, phosphorus 0.06, and manganese 0.16 per cent., but with the silicon varying from 0.35 up to 0.80 per cent. When the silicon was 0.56 per cent., the length of the bar did not vary during the time of an ordinary anneal. Below this figure contraction took place, and above 0.56 per cent. a growth.

As was to be expected on repeated annealing, which means elimination of carbon, the bars contracted until a standard figure was reached. This is shown by Table IV, a study of which shows that the pitch of the links can be varied by slight difference in chemical composition, and also by different annealing times.

Table IV.—*Keeps' Bars Annealed in Light Ovens.*

Lab. No.		549/779		558/800		559/801	
Si. %		0.56		0.59		0.65	
Original length of bar		11.868 in.		11.865 in.		11.873 in.	
	Length.	Difference.	Length.	Difference.	Length.	Difference.
1st Anneal.	11.868	.000 in.	11.869	.004	11.903	.030
2nd Anneal.	11.842	.026 in.	11.847	.018	11.893	.020
3rd Anneal.	11.848	.020 in.	11.846	.020	11.891	.018
4th Anneal.	11.843	.025 in.	11.842	.023	11.887	.014
5th Anneal.			11.842	.923	11.875	.002
Bend.			180		180	
			Unbroken.	Unbroken.	Unbroken.	

* Whilst the silicon varied, the rest of the analysis was constant at T.C., 3.4; S., 0.28; P., 0.06; and Mn., 0.16 per cent.

Electric Furnace Developments.

By Frank Hodson.*

The early history of the electric melting furnace is very closely interwoven with the names of Siemens, Hale of Philadelphia, Ferranti, Moissan, Cowles, and closely following come Colby of Pittsburgh in 1887 with an induction furnace for melting metals—Heroult, Girod, Keller and Chaplet in France. Soderburg, Hiorth and Harden in Norway, Gronwall, Rennerfelt and Kjellin in Sweden, Rochling-Rodenhauser, Frick, Natthusius in Germany, Stassano and Catani in Italy, Hering and Snyder in America.

Many distinguished scientists and metallurgists have followed the early pioneers and helped development along, but broadly speaking the chief types of furnace in use to-day originated with the above. Heroult, the plain arc furnace—Stassano and Rennerfelt the indirect arc, Girod and Gronwall the arc-resistance, Colby, Rochling and Hering the induction furnace.

The Growth of the Industry.

In 1904 the Haanel Commission, appointed by the Canadian Government to investigate electric furnace pig-iron and processes in Europe found only four what might be termed "commercial electric melting furnaces." These were the Heroult furnace at La Praz, France—the Stassano furnace at Turin, Italy, a Heroult furnace at Kortfors, Sweden, and the Kjellin induction furnace at Gysinge, Sweden. With the exception of the last which was used for melting down pure materials, these ancient landmarks were making electric steel exactly as we are to-day—same kind of charge, same electrical principles, same silica, lime, iron oxide and carbon on slag, and producing equally good steel.

At the end of 1914 the number of electric furnaces had grown to 114, with 30 or so additional ones under construction—14 of these 114 were credited to the United States—the bulk of these furnaces then, as now, were arc furnaces. The total charge capacity of the furnaces installed to this time was about 250 tons.

The 1923 "Iron Age Annual Review," gives the number of furnaces in America and Canada as 406, and one furnace, the new "Greaves-Etchells" top or bottom connected furnace at the Ford Motor Company, has a capacity of 60 tons.

The largest furnace installed in 1914 had transformers of 1,500 kw., although it is only fair to say a 3,000 kw. furnace was then contemplated. The "Greaves-Etchells" Ford furnace has Westinghouse transformers of 12,000 kw.—probably more power than all the existing furnaces to 1914.

Many observers to-day are apt to think that electric furnace growth has reached its limit in certain directions. A far-seeing minority, recognising some of the limitations that have for many years held back electric furnace development, believe that we are merely on the fringe of electric furnace possibilities. Some of these limitations to natural growth and development, such as cost and availability of power, knowledge of building and operating electric furnaces are being rapidly removed. The electric power companies are beginning to look for and encourage electric furnace installations—although from the point of view of a builder of furnaces this might come much quicker—many power suppliers are willing to make very special rates for furnaces, and the linking up of super-power schemes, and of new hydro-electric developments all mean less limitations to furnaces.

On the design and operation end we are daily getting more knowledge, the unfit and incapable are being weeded out, and both building and operation of furnaces is fast becoming looked upon as a real science, not the half-baked efforts of the man who has once worked on a furnace and so thinks he can design a new type, nor of the melter who thinks throwing scrap into a furnace and pouring same into a ladle constitutes him as an authority on steel making.

There is one limitation to furnace development that is entirely physical—the maximum size of furnace has hitherto been looked upon as being governed by the number of electrodes and of the largest jointed carbon-electrode that is commercially made for electric melting furnace use, which is 24 in. dia.

The most prevalent and accepted type of furnace is the Heroult, which covers all three-top-electrode furnaces arcing on to the slag or metal: there are excellent electrical and metallurgical reasons why it is not advisable to put more than three electrodes in such a furnace, and it therefore follows that when one reaches the ampere carrying capacity of three 24-in. electrodes, one also reaches the maximum quantity of metal one can melt or superheat in a reasonable time. Mr. E. T. Moore, electrical engineer of Halcomb Steel Company, Syracuse, New York, and one of the best informed men in America in the science of electric furnaces, states that in his opinion the maximum satisfactory size of a large three-top electrode furnace for cold-melting should be 15 tons, and for hot charges 40 tons.

This limitation in size of furnaces has been removed in two ways—first, by use of the "Greaves-Etchells" principle of furnace and transformer design which permits of any multiple of two electrodes—the large Ford furnace has eight electrodes—and by the Soderberg self-baking electrode.

The Soderberg Electrode.

The Soderberg electrode is not limited to 24 in. dia.—electrodes up to 60-in dia. have been in successful operation for some years, and when one considers that a Soderberg electrode will carry twice the amperage per sq. in. of a standard amorphous carbon electrode, it will be seen that the possibilities of getting large amounts of current into furnaces are not merely a question of 24 in. against 60 in. but of double that ratio. It should not be assumed, however, that 60 in. is the limit in size of Soderberg electrode, it just happens to be the largest size in operation to-day.

It is quite possible that the advent of the Soderberg electrode, which can be built in a variety of shapes, solid or hollow—may completely revolutionise our present ideas on furnace design, and on application of electricity to smelting and melting. As an example considerable work has already been done on the use of large hollow electrodes, the charge being fed down the centre, and what is probably more important, making up a continuous Soderburg composite electrode in which the actual charge, say, of iron ore, zinc ore, etc., is mixed with the binder and forms the electrode. In the case of iron ore the resistance of the ore to the passage of current and the presence of carton will result in reduction of the ore to low carbon iron sponge before it reaches the arcing zone of the furnace, where it can be readily converted into low carbon iron or steel. Coming back to electric steel furnaces, the over development due to war conditions is being very rapidly taken up, and will probably cease to be a factor in the near future.

The use of large furnaces for refining and superheating both steel and iron is a logical development that is bound to come—the removal of difficulties cited previously will hasten matters, and improvement of the general steel business will further help.

The writer is of opinion that such furnaces will follow along general open-hearth lines—fixed furnaces—Soderberg continuous electrode and costing little more than present large open-hearths. One of the possible difficulties will be that electric furnace slag on a basic furnace is more difficult to control than basic slag in open-hearth furnace. However, progress will not be held back for such reasons—it is a problem that good metallurgists can and will solve.

Acid-lined furnaces would have no such objection, and even if used merely as a method of superheating iron or steel and removing occluded gases,

* Mr. Hodson, an old student at Sheffield University, is President of the Electric Furnace Construction Company, 1,015, Chestnut Street, Philadelphia, U.S.A.

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oxides, slag and dirt, large electric furnaces are going to justify their adoption.

The quality of both iron and steel can be immensely improved by merely superheating—the experiments made at the River Rouge Works of the Ford Motor Company under Mr. Sorenson on electric superheating of blast furnace iron have proved conclusively that such superheating gives a product entirely different from the iron put into the furnace. Small intricate castings were made having mechanical strength far in excess of cupola iron. The same process could well be applied to cast-iron pipes, moulds, large iron castings to withstand pressure or excessive wear and many such purposes. It is time foundrymen made a better iron than the ancients—yet present-day cupola practice of ironmaking differs little, if any, in essential principle from the first-known records of ironmaking. Some are sufficiently unkind to say that the ancients made it better than we do now—certainly the iron statue at Delhi and many other similar examples could be quoted in their favour.

The electric furnace, when used either to melt down cold scrap or to superheat hot iron made in some other process, undoubtedly makes possible the production of sound, dense iron free from blowholes, slag, gases and dirt. The amount of power used in superheating is small, and in many cases saving on rejections alone will pay for such power. The work that has been done on iron, with the possible exception of the Ford experiments, has been in small electric furnaces making iron for piston rings, valves, steam fittings, bottle moulds and parts where special quality iron is necessary. There is probably, however, a much larger field in large iron castings and in malleable.

The writer is confident that by adjusting analysis somewhat an electric furnace malleable iron could be made that could be annealed in less than half the time now occupied, and give at least 25 per cent. better tests. A very large tonnage of steel castings is now being made in acid electric furnaces of from ½ to 6 tons capacity. Such furnaces are usually of the standard 3-top electrode type, designed with high melting down voltages and excess of transformer capacity to insure quick melting. No attempt is made in such furnaces to do much more than melt down scrap and pour into castings, but they appear to fill a want.

The furnaces are easily handled—experienced steelmakers are not so essential as in the basic steelmaking process, and castings can be made at competitive prices. The only trouble is that anybody and everybody can make such castings, and real steelmaking knowledge is not a paying proposition. However, such furnaces can and do make a very good steel, and a large number have been installed in the last two to three years.

For making tool steels and higher grade steels the basic furnace is still pre-eminent, and whilst, on account of general steel trade depression and over war production, few new furnaces have been installed recently, the electric furnace is now one of the chief factors in alloy steel production.

The increasing use of rustless (chromium) steel and other alloys, both in steel and castings, will mean more electric furnace installations.

In conclusion, might say that whilst electric smelting of iron ore is not generally feasible in U.S.A., it is receiving considerable attention from South America and Canadian companies, who have cheap hydro-electric power and good iron ore.

Probably some of the developments outlined may take years to mature, but the writer believes they are logical and based on fact, and not theory. Present plants have large investments that cannot readily be changed, but better and cheaper iron and steel is being called for, and cheap electric power, permitting the use of large economical electric furnace units, will help solve some of the steelmakers' problems.

Mr. W. E. Walker, who, for about 12 years, has been in the service of Sir. W. G. Armstrong, Whitworth & Company, Limited, and latterly has been in charge of the brass department at the Scotswood Works, left England, last week, for Italy, to become manager of the Pozzuoli Works, Naples, owned by the Elswick firm.

Effect of Ingot Moulds on Steel.*

In this Paper the author shows that segregation, the formation of dendrites and the distribution of intergranular material bear definite relations to the rate of cooling and the solidification of steel in the mould. The results presented by the Paper were based upon a comparison of ingots cast in both iron and sand moulds with a chill respectively of about 5 to 1, about 3 to 1 and 1 to 1. The author shows that steel most rapidly solidified in the mould responds most easily to heat treatment. Forging improves the physical properties of steel cooled slowly in the mould, but it cannot correct the bad effects resulting from the segregation of intergranular material. It is the author's contention that, while steel should be cast in the mould as cold as possible, in order to obtain uniform structure and chemical analysis, higher temperatures in the furnace before tapping will help to rid the steel of occluded gases and foreign non-metallic inclusions, and give a better and more uniform solution of alloys and other desirable constituents. The best results are obtained by getting the steel hot in the furnace and making all the additions possible before the steel enters the ladle. In some cases the steel is cooled in the furnace, but more often it is tapped into the ladle, where it is held until the proper casting temperature is obtained.

Mr. Emil Gathman, in a written contribution discussing the Paper, stated that for many years he had considered the rate of cooling of an ingot as a fundamental factor in determining the chemical as well as the physical characteristics of the solidified steel casting, and he said that all his ingot-mould designs have been based upon this theory. He proceeded to describe the steps which have led to his advocacy of the big-end-up mould. More than five years ago his company had advised steel makers that an increased ratio of mould chill beyond 2 to 1 was of real value only when employed in conjunction with an ingot of inverted, pyramidal form and suitable taper, or the so-called big-end-up type. In the big-end-down and uniform-chamber moulds an air gap forms within a very short period between the outer peripheral solidified skin of the ingot and the mould walls, which retards the transmission of heat from the ingot to the mould wall irrespective of the ratio of chill. His company has found that a very heavy metallic mould wall, when used in conjunction with the big-end-down ingot, actually increases the time of solidification of the interior of the ingot.

Mr. George A. Dornin said that he had recently split a forging steel ingot cast in a big-end-down mould of standard dimensions on which a refractory hot top had been used. This ingot weighed approximately 3 tons, was made from a deoxidised heat of steel, was poured at the lowest possible temperature, and hence may be regarded as good practice in a big-end-down ingot. It was approximately 20 in. square. Along the axis of this ingot and extending within 10 in. of its bottom end was a flawed zone approximately 5 in. square. This zone in one plane contained more than 25 actual flaws varying in length from ¼ in. to ¾ in. Had this ingot been rolled into bars for charging, not 1 per cent. of it would have been sound, and it was representative of the best that could be obtained with a big-end-down ingot. Heavy mould-wall chill was of value to industry in the production of sound steel only when it was employed in conjunction with the big-end-up mould and when it was used as an aid in outwardly distorting the lines of freezing ingots from bottom to top, and hence was only of value when used progressively.

Messrs. H. Bridgwater & C. E. Bridgwater, iron and steel merchants, 32, Priory Street, Dudley, trading under the style of Henry Bridgwater & Son, have dissolved partnership. Mr. C. E. Bridgwater will continue the business.

* Paper read by Mr. Wm. J. Priestley (metallurgical engineer Electro-Metallurgical Sales Corporation, Pittsburgh, Pa.), before the American Institute of Mining and Metallurgical Engineers at New York.

The Moll Design of Open-Hearth Furnace End.

In existing designs of open-hearth furnace, when melting a cold charge, difficulty is experienced in obtaining that great essential—a high combustion temperature, which in turn, helped by high flame velocity, determines the duration of the heat, and hence the economy of the process. The means of attaining a high combustion temperature are: (1) A high degree of pre-heating of both gas and air; (2) the use of catalysors in the gas (by blowing pulverised coal, coke, lime, etc., into the furnace); and (3) by attaining the best possible mixture and combustion of the air and gas in the smallest possible space with the smallest possible volume of excess air.

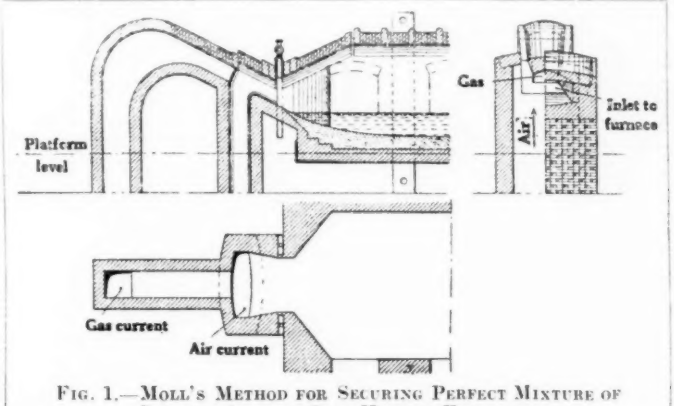

Fig. 1.—Moll's Method for Securing Perfect Mixture of Gas and Air for Open-Hearth Furnaces.

In his new design of open-hearth furnace end, as described in a recent issue of "Stahl und Eisen," Herr Hermann Moll adopts the third of the above-named methods. To secure a perfect mixture of gas and air before its admission to the hearth, he leads the gas and air into a common flue (the mixing flue), and thence into the hearth as shown in Fig. 1. The end of the furnace is so designed that the gas flows without change of direction, and impinges at right-angles on the air current flowing upwards. The bottom of the gas flue and that of the leading-in flue are approximately in the same plane, in order to prevent the air from flowing away below the gas-stream and so setting up a refining action when such is not intended (pig-iron and ore process). The arrangement is such that at the meeting place the air current is spread out so much and led so high that the air completely envelops the gas like a ring much in the same way as in the flame of a Bunsen burner. This prevents the gas current from breaking away sideways or from hugging the arch of the flue.

Fig. 2 shows an alternative design arranged on the same principle. In this case the air current enters from behind and also envelops completely the gas-stream entering the mixing and leading-in channel from underneath. This latter arrangement, of course, presupposes that the gas chambers are situated inside and the air chambers outside. It has the advantage from a fuel economy point of view that the air chambers can be continued to above the platform level, thus allowing a large increase in the height of the effective chequer-work even with a low platform or high level of subsoil water. Special slag-chambers, moreover, can be dispensed with in this case as the gas flue can be arranged so as to serve the same purpose, and the slag can be tapped off easily in liquid form.

Numerous temperature measurements made in all the furnaces of the Rasselstein works and elsewhere have proved that with this new design of furnace end the gas and air, even when highly pre-heated, can, contrary to prevailing opinion, be conveyed together without the danger of pre-ignition and the consequent risk of damage to the brickwork. The writer came to the conclusion, however, when designing his furnace end, that it was not possible both to mix and ignite suddenly pre-heated gas and air, because the necessarily high rate of flow of the two media would prevent this. Time must be allowed for mutual diffusion before mixing can become complete, and until such mixing is completed combustion cannot take place, nor can it be finished entirely until the process of mixing is terminated. A cone is formed as in the case of the Bunsen burner, only in the present case it is not a combustion cone, but a diffusion cone inside of which only unburnt gas is present. The base of the cone is formed by the outlet orifice of the gas flue, while the height of the cone is determined by the speed of the emerging gas and the velocity at which the air impinges on the gas current (the speed of diffusion). By varying these velocities, the length of the cone of diffusion can

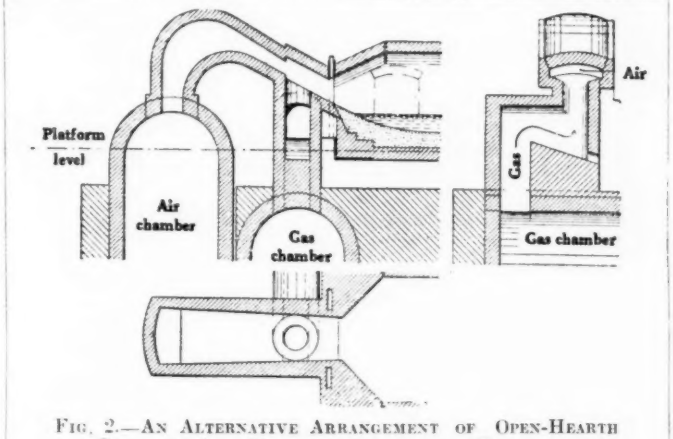

Fig. 2.—An Alternative Arrangement of Open-Hearth Gas and Air Inlets, based on the Principles Adopted in Fig. 1.

also be varied, thus enabling one to vary the place of combustion. The fact that such a diffusion cone is formed, and that it can be varied according to the velocities of gas and air, even when these media are pre-heated above their ignition temperature, proves also that combustion cannot take place spontaneously. The diffusion velocity can be still further increased by not allowing the gas and air to expand, but by compressing the mixture by choking it in the leading-in flue. By this forced conveyance together of air and gas it is possible to work with the theoretical, *i.e.*, minimum quantity of excess of air, while by suitably regulating the rate of flow of air and gas, and varying the diffusion cone by suitably selecting the dimensions of the leading-in flue, it is possible to begin and finish the main phase of combustion in the hearth itself without producing hurtful overheating in the leading-in flue.

The author claims that every possible favourable condition exists for securing satisfactory combustion with his type of furnace head. It is a well-known fact that, besides differences in temperature, direct heat transmission by convection depends upon the velocity and the consequent turbulence of the flame, because the eddies formed thereby quickly allow fresh gas particles to come into contact with the bath of metal, to which they give off their heat. The turbulence effect is important also, because gases conduct heat very badly. The author, therefore, gives his flame the highest possible velocity by suitably dimensioning the leading-in flue, and makes the flame impinge on the bath at a very steep angle, thus braking the kinetic energy of the mixture and setting up turbulence.

Furnace ends of the new design are said to be extremely easy and cheap to construct. The saving in masonry and anchoring works out at about 60 to 70 per cent. of the ordinary type of furnace ends; whereby, of course, much time is saved in repair work. A further considerable saving in repairs, etc., is due to the fact that the masonry of the new type of furnace end can be very quickly heated up compared with the heavy mass of masonry of the ordinary type of furnace end, which has to be heated up very slowly and carefully in order to prevent cracking of and other damage to the brickwork.

One steel works using five furnaces with ends of the first described of the two alternative designs has attained, on 411 heats, an average throughout time of 5 hours 3 min. in the case of 10-ton furnaces having a yield of 11 tons, and an average period of heat of 5 hours 13 min. over 482 heats with the 30-ton furnaces with a yield of 31.6 tons. The best results were obtained with the 10-ton furnaces with an average of 37 to 38 heats a week, while the 30-ton furnaces gave 28 to 30 heats a week. In another plant, at which a number of 30-ton furnaces are at work, an average of 4.44 tons per hour are produced when working without pig-iron, or 5.3 tons per hour when working with 21 per cent. of pig-iron.

The Tensile Properties of Aluminium at High Temperatures.*

By Thomas Martin, M.Sc.

Summary.

Tensile tests on two qualities of aluminium, at temperatures up to the neighbourhood of the melting point, show a rapid diminution in the strength of the metal, with corresponding increase of ductility, up to about 325 deg. C. At this point a marked increase of ductility takes place, which is attributed to a sudden increase in the rate of recrystallisation. With further rise of temperature the loss of strength continues at a less rapid rate.

A comparison of the results for the cold-worked and fully annealed material indicates that up to 200 deg. C. the added strength conferred by cold-work is well maintained, but at higher temperatures the rate of softening is such that the only reliable indication of strength is that obtained from a test on the fully-annealed metal. The results bring out the importance of *quantitative* observations of the time and temperature conditions of annealing of a cold-worked metal as a preliminary to tensile testing at high temperatures.

The tests on the less pure metal show that the effect of the impurities present is to make the metal *stronger but less ductile* at all temperatures, while the marked increase in ductility *occurs at a temperature fully 75 deg. C. higher.*

Tests at the different rates of extension obtainable on ordinary machines indicate that at the atmospheric temperature differences of maximum stress due to this cause are within the limits of experimental error. Tests at two different rates, however, *at all temperatures above the atmospheric*, show that the maximum stresses observed for the faster rate are greater than those for the slower rate, the effect increasing with the temperature. No differences in the readings of elongation and of contraction of area, due to rate of extension, could be observed.

The maximum stress results obtained in these tests, in conjunction with those of Dickenson for steels, indicate that the time factor in tensile testing, at all temperatures above the atmospheric, is of greater importance than has hitherto been suspected, and that special methods of testing must be devised to determine the ability of aluminium to withstand prolonged applications of stress at elevated temperatures.

* A Paper presented to the Spring Meeting of the Institute of Metals.

British Industrial "Safety First" Association.

The annual report of the above Association, which was presented to members at their fifth annual general meeting held at Caxton Hall, Westminster, recently, was a very encouraging document, demonstrating, as it does, the steady progress that the "Safety First" movement is making in industrial circles. Increases of 13 per cent. in membership and 25 per cent. in subscriptions must be considered satisfactory, especially in view of the general trade depression last year.

Part of the work of the Association is the preparation and distribution of posters, of which 80 different designs have been made, and 100,000 copies circulated amongst its members. Testimony to the valuable effect of these posters is forthcoming from all quarters, and the Monthly Poster Suggestion Competition has attracted numerous entries from the workers who are showing a marked interest in "Safety First" methods.

In conformity with a resolution passed at the last annual general meeting, the title of the Association as and from January 1, 1924, becomes the Industrial Branch of the National "Safety First" Association, which has been formed to link together all the separate "Safety First" activities. The interests of members will not be affected by this change in name.

The latter part of the report gives accounts, supported by figures, of satisfactory results achieved by numerous members, clearly establishing the claim of the Association that good results inevitably follow from their work.

The annual meeting of the Scottish Branch of the Institute of British Foundrymen was held in the Royal Technical College, Glasgow, on March 22. Mr. A. Lawrie, chairman of the branch, presided. Mr. John Bell, secretary, submitted the annual report, which showed that the total membership was 236. The outstanding feature of the session was the holding, for the first time in Scotland, of the examinations under the trust of the John Surtees Memorial. Mr. J. Affleck was elected president for the ensuing year: Mr. A. Mearns and Mr. T. Bell, vice-presidents; Mr. Gardiner, Mr. Robertson, and Mr. Winterton, members of council; and Mr. J. Bell, secretary. Professor Mellanby afterwards gave an address on "What Engineers Want in Diesel Engines," and short papers were read by Mr. James Charters, who dealt with "Some Foundry Faults as Seen by a Patternmaker," and by Mr. John M'Eachan, who spoke on "Problems in Oil Sand Cores."

Interpretation of Chemical Specifications for Iron and Steel in Relation to Analytical Accuracy.*

By C. H. Ridsdale.

The author stated that exploration of the work of the British Chemical Standards' Movement had revealed data not available before, which should have practical bearing on the interpretation of chemical specifications. It was not merely a matter for chemists, and already wide-spread interest had been taken and opinions expressed, and the views of their members were now sought. He pointed out that rejection or delay in accepting material ultimately was paid for by the consumer, and that when interpretation of specifications was unnecessarily rigid their difficulties in competing increased, and the country suffered. He quoted from Mr. Samuelson's Presidential address:† "Two railways, over whose lines many of the same trains run, vary by 0.02 per cent. for both elements" (phosphorus and sulphur). "If one of these railways be not endangering the lives of its passengers, the other is needlessly increasing the cost of making steel rails, and restricting the use of certain ores." He was not dealing with this vital question, but merely cited it to show what happened whether rejection or delay was due to real or imagined necessity.

Bringing certain facts before them, however, was not an attempt to relax specifications, and the author recognised that although foreign makers on the whole had more latitude allowed them, engineers in being rigid were aiming at maintaining a well-earned reputation for high quality and safety. They specified chemical limits which, from experience or from what metallurgists had led them to believe, they considered desirable. For carbon manganese and silicon they usually gave an upper and a lower limit, arranged to give certain strength and toughness and to meet the manufacturers' unavoidable working margin, but for what were regarded as injurious impurities only a maximum limit was given, so low that its effect was negligible for the purpose.

Engineers then looked to the chemist to tell them whether or not the materials came within these. The author considered one case—"S or P not to exceed 0.03 per cent." in steel, though it applied equally to other figures for ore, cast iron or steel. The maker, of course, wanted to work to this, he did not wish after the material was made to have it rejected, so he looked to the engineer not only to tell him exactly what he wanted, but give him means for making sure as he proceeded with manufacture that he was doing this. The engineer gave him exact drawings, gauges, templates, measurements, etc., for section or length as well as the weight—all had definite standard values, and definite allowances were made for variation from them—so he could know with certainty before submitting a batch whether his material was right in those respects.

For composition, however, he had nothing definite to go upon, all that was given him, and he had to work to, was a figure on paper that had no exact meaning; its value was determined arbitrarily after the steel had been made by analytical operations subject to ever varying personal and other factors so that another test of the same sample might yield a different result. So, although the maker's own chemist might find the material right he could never be sure it would not be rejected. It was only because this state of affairs had existed from the first that the absurdity of it was not obvious. It might be replied that the differences of the buyer's, maker's, or the reference chemist from absolute accuracy, were so slight as to be of no importance. This might be true as far as the actual effect on the properties of the material was concerned, but such small differences near the border line—quite within the range of working of good chemists—might be enough to cause rejection of it.

Chemists' Accuracy Influences Specifications.

Analytical chemistry was able to determine composition with considerable accuracy, and, owing to this and to the extremely small quantities dealt with, gauging by it was set to a very high degree of exactitude. If chemists had not been able to test so accurately specifications would not have been so stringent. For the same reason exaggerated importance was apt to be attributed both to the influence of small quantities of impurities and to trifling differences in results; no allowance, however, was officially recognised for differences which analysts usually gave in practice, which were distinct from differences arising during manufacture and recognised as inevitable.

If, instead of the maker having to work to and be judged by an unfixed and unascertainable (by him) value, the composition figure was specified in terms of a definite standardised sample the values of which had already been determined, it would be much more satisfactory for all concerned. This would be tested side by side with the sample of steel made, and by its agreement with or divergence from its acknowleged standard figure would at once reveal whether or not the working and results of both were correct.

It was difficult to understand why engineers did not yet in specifications refer their figures to such a standard now that a good range was available, and why makers did not insist on it. In the preparation of standard analysed samples important factors which tended to differences between chemists in ordinary work were removed, and there was direct proof that these measures were effective. The chemists were men of status using what they regarded as the most reliable methods with the greatest care. Yet whenever a large number (10 to 20) tested the same sample the final carefully considered results had shown an appreciable variation. The work of three other known movements bore this out.

In the investigation referred to the differences were taken out for the 10 to 20 final tests for each of the 100 or more standardised results; and the averages of the differences for each element from all these showed a range of variation. Hitherto on work under ordinary conditions one had regarded such differences as bad work or choice of a bad method by the "other fellow." But with such a mass of incontrovertible evidence of difference always occurring between good chemists—although working with such samples and with extreme care—provided there were a good many of them, the whole aspect was altered. Although no doubt mainly due to limitations of the methods themselves and differences of judgment on the part of the chemists, clearly some of the results must be wrong, but who could say which?

In these circumstances the question arose: Was there justification for regarding any result by one or even two or three chemists as right, except to within a similar range of variation? Then, was it reasonable that material should be rejected solely for wrong composition, when the variation from the figure specified did not exceed that by which the reference or any chemist might be in error? This question was in line with the essential objects for which their co-operators had undertaken the production of standards. A reference chemist might know his results would condemn material, and though he felt convinced the small difference from specification would not be detrimental, he could not modify it. Or a works' chemist might find himself regarded as wrong, and steel he felt certain was right be condemned, but if the engineer was rigid he had no redress.

Proceeding, the author said these facts and considerations were submitted to the general meet-

* Abstract of Paper read at a joint meeting of the Cleveland Institution of Engineers, the Newcastle Section of the Society of Chemical Industry, and the Institute of Chemistry, at Middlesbrough.

† "Journal of the Iron and Steel Institute." Vol. I, 1922, page 30.

ing of the British Chemical Standards' Movement, held February 9, 1923, and their views, embodied in Resolution 4, stated "That as co-operators in the British Chemical Standards' Movement, we believe that it would be useful to manufacturers and users of steel, cast iron, etc., to have a definite expressed opinion as to the limits of accuracy of analytical methods usually met with in practice as indicated by the differences found among the results obtained by different qualified chemists working on the same sample, since these represent fairly the limits of difference which should be accepted; and we consider that the rejection of steel or cast iron is not warranted on chemical analysis alone, merely because the result found for a constituent differs from the round figure specified by an amount within the tolerances so obtained; and we request the committee in conjunction with organisers to obtain the opinion of the whole body of co-operators and such other persons as they may think desirable, to establish a list of such limits, and to report to a future meeting of the co-operators."

Chemical Tolerances.

In accordance with this a circular letter, and an opinion slip, duly approved by the committee, were sent out to co-operators and users of standards, and also to a few others whose opinion would be of value—about 550 in all—comprising chemists, metallurgists, engineers, manufacturers representing iron and steel makers and users, and independent men in the British Empire and other countries, and they were asked to say whether they thought there was any more accurate and reliable way of determining "the limits of accuracy of analytical methods usually met with in practice as indicated by the differences found among the results obtained by different qualified chemists working on the same sample" than by taking out such differences between the chemists in the analysis of the respective standards.

Then was given a table showing that the "tolerances which would seem reasonable for analytical determination of composition" were really very small when compared with those actually granted for other properties of material, such, for instance, as variation in weight and of length. The tolerances tentatively suggested were, it would be seen, slightly above one-half the range of variation found with work under exceptionally favourable conditions.

The tolerances as to weight and length were: weight 1 per cent. and length 0.05 per cent. Tolerances for composition are given in Table I.

Table I.—*Tolerances Officially Granted for Composition, and those Proposed.*

	Range.	Actually found.	Suggested.
	Per cent.	Per cent.	Per cent.
Carbon	Up to 0.35	0.0250*	0.015
	0.36—0.75	0.0330	0.020
	0.76—1.20	0.0500	0.025
Silicon	Up to 0.10	0.0250	0.015
	0.10—0.20	0.0320	0.020
Sulphur	Up to 0.08	0.0077 (0.008)	0.005
Phosphorus ..	Up to 0.05	0.0062	0.005
	Over 0.10	0.0120	0.007
Manganese (Plain carbon steels) ..	Up to 0.45	0.0210	0.015
	0.46—1.00	0.0480	0.025
Alloy steels, cast iron	Up to 0.70	0.0500	0.030

* The percentages of variation found and suggested for composition are (as in the case of weight and length) percentages of the whole 100 units, not of the total of the particular element determined only.

Example Given.

A concrete example was given which would work out in practice as follows:—At present, if A makes some steel against a 0.03 per cent. specification, which on careful testing he finds contains 0.029 per cent., but the purchaser B finds 0.034 per cent., particularly if an independent chemist also finds 0.034 per cent., it is likely to be rejected, and considerable trouble may result. This 0.005 per cent. difference being, however, within the range of accuracy of testing, it would be quite reasonable to accept it, for it is practically certain that if, say, 10 to 15 chemists of standing tested it, several would find as low a result as A had done. Therefore, if the matter was viewed rationally and the tolerance clauses were generally adopted, the steel would be accepted without hesitation, and the trouble avoided. In pointing out these matters the British Chemical Standards' Movement Co-operators were not seeking to relax or modify the limits allowed by specification—this was no part of their business—and makers and sellers of material would be very unwise to act on such a supposition and allow themselves greater latitude in manufacture.

General Opinion Favours Tolerances.

Out of all the 550 to whom opinion slips were sent, not one had objected outright to the principle, though several said the tolerances were not sufficiently large, or raised partial objections, all of which the author gives. Others said they did not feel disposed to offer any opinion. But the vast majority approved both of the principle and the amounts; many, besides such as were quoted, had also written in favour of the effort to get the matter considered. Quite a number had written long and careful replies.

The types represented in the replies, when analysed, showed: (1) Iron and steel makers who sell to specification, 34 per cent.; (2) iron and steel users who specify or buy to specification, 46 per cent.; (3) independent consulting engineers, directors, managers, referee chemists, professors, officials of research associations, etc., including the United States Bureau of Standards, one of whose officials has simultaneously promulgated the idea there, 20 per cent. So these clearly were thoroughly representative of the interests concerned.

A number of replies were from prominent officials abroad, *e.g.*, India, South Africa, etc, of which the author gives a summary or extracts, and where permission had been received the names of the writers also, as this added to the value of their remarks. In addition to the very large number who had signified their approval merely by signing the slip, three correspondents thought all the tolerances suggested, and one, those for carbon only, to be too low; whilst one thought all tolerances, and one of those for sulphur and phosphorus only, to be too high. Two expressed the opinion that the decision (as to rejection) should be left to metallurgists, one adding that chemists if allowed to do so would settle any differences amicably. One writer had not realised that the closeness of agreement of results in his own laboratory was something quite different from that occurring between a large number of chemists. One thought that if tolerances were adopted specifications would become more stringent, whilst another thought makers should work to lower limits.

This would seem very illogical and unfair, as "tolerances" would only be a recognition of a state of affairs—slight uncertainty as to the exact value which had always existed. It did not mean that the steel, etc., became any more impure on that account. They had heard the case, also what were the views of a large number of people representing different interests and schools of thought, so he wanted their views also, particularly on certain definite issues. He had brought this matter forward because he had come across the facts, and from his independent position it would be known that he had no axe to grind. A works chemist could not well have brought it forward nor could he himself pending any case on which he was engaged. He was not out to advocate anything but what facts showed to be a rational course, so he wanted their views also, particularly on certain definite issues. The fact of these differences between chemists, even when doing the most careful work, could not be gainsaid, and showed that they caused considerable trouble, and did not improve the status of the chemist in the eyes of engineers and commercial men.

What were they going to do about them? Did they really matter in practice? A difference of 0.005 per cent. might look a lot as compared with a total of 0.03 per cent., but it was really only one twenty-thousandth of the unit.

Was not determination of composition to such a degree of accuracy really very fine working? And was not any idea to the contrary largely due to thinking of the figure 5 rather than of the distance it was to the right of the decimal?

Continuing, the author said to avoid confusing

the issues he would not discuss the question of how far such a difference in sulphur or phosphorus as 0.005 per cent., even if it were an increase, could detrimentally affect the material, when even the 0.03 per cent. specified was evidently regarded as a negligible amount for the purpose.

Another way of dealing with the matter seemed to be for chemists not to report to the third decimal place, at any rate by less than 0.005 per cent. at a time. An engineer might say "if 0.001 per cent. or 0.002 per cent. does not really matter, or you can't be sure within that, why do you report it?" The practice no doubt had arisen from chemists being men of very precise habit, and when they worked out a weight or reading their love of accuracy led them to do this; and, having taken the figure to a negligible point, they had not to make up their minds whether to express the result by a higher or lower round figure. Also there was an instinctive dislike to curtailing figures. The expression in that way was, however, mathematical rather than technical.

Standardised Samples.

However, if the present custom of reporting (to the third decimal point) was to be continued, would it not seem to be imperative to allow such differences as the tolerances? And was it not for chemists rather than engineers or commercial men to define what a given figure meant, and how closely it ought to be interpreted? If, however, they contended that figures should be reported to such a degree of fineness, and that these differences did matter—which seemed to be the view held—the only way was for chemists still further to improve their working. In that case was it not imperative that everything should be done to facilitate the desired exactitude?

To this end ought not engineers to supply, or at least refer to definite standards obtainable by all (which should serve equally as a check on the works or Reference chemist's working), just as they stated the composition itself; in fact, as an inherent part of and invariable concomitant with this, ought not both makers and chemists to regard these standards not merely as a convenience to be supplied or used at option, but as a necessity which they had a right to demand. So, too, as regarded both the choice of analytical methods and the exact way of conducting them. Whether they liked it or not, did not the facts all drive them to the conviction that for commercial purposes these must be standardised? And, further, since the accuracy of all methods depended on a number of factors, very slightly different conditions affecting the result, and the more operations the more chances of variation, could they hope to get closer agreement except by mechanicalising the methods also as far as possible, for then all chemists would be working on the same lines, under the same conditions, and with the minimum of variable factors?

This was the real value of and justification for such methods rather than speed, total time saved, or economy. Although still to some chemists this idea was repugnant, very many—a constantly increasing number—recognised the necessity of it, and were using such methods. Whatever might be the exact means by which the differences and difficulties referred to in the Paper would ultimately be removed—it was not to be expected that it would be achieved all at once—the more the subject was ventilated, and discussed between engineers, managers and chemists, the sooner would this come about. They had as an example of evolving certain definite lines out of the somewhat chaotic state of affairs, when each engineer did as seemed good to himself, the splendid work of the British Engineering Standards Association.

True, they only made recommendations, not laws, but these were becoming more and more effective every day, and they could only expect the B.C.S. Recommendations to take effect in the same way. Might not the questions as to the interpretation of chemical specifications be similarly cleared up by engineers and chemists if they would unite on the same lines?

DISCUSSION.

A discussion on the Paper took place, from which we have made the following abstracts:—

Mr. H. B. Toy, opening the discussion, said the Paper was of great importance and interest to mine owners, blast-furnace managers, steelworks managers, chemists, engineers and inspectors. The object of the engineer in specifying the tolerances was to safeguard the lives of the general public, and as to whether it was very difficult to keep within the limits of that specification was a matter which those connected with steelworks' laboratories were more able to deal. He agreed, however, with Mr. Ridsdale in one respect. Steel, in his opinion, should not be supplied entirely on a chemical analysis, as between the chemical test and the physical test the more important of the two was certainly the physical test.

Mr. Hanson did not agree with the need for tolerances. If a customer asked for a certain steel he saw that he got it. If they stuck to the specification, and the laboratory was at all well conducted, he did not see that there could be any trouble. They had to give the buyer the steel that he wanted. He thought it *infra dig* for the chemist to ask for tolerances. They could provide steel to do a certain thing, and the tolerances would not be worried about.

Mr. R. H. Archer Coulson said that they had already wide tolerances, and to extend them was opening the door to slack work. They ought to be able to make steel to a given specification.

Mr. C. W. Holmes (Birtley) declared that in the cast-iron industry such fine limits as were mentioned in the Paper were quite impossible, and errors in sampling were much greater than errors in analysis. He suggested an investigation of founders' methods of analysing iron and steel and the adoption of a standard method.

Mr. Ridsdale, replying to the discussion, said he had not expected unanimity of opinion. He was merely an outsider watching the game. It did not matter to him whether they adopted tolerances or not. It was perfectly true it was all a question of toleration as between the buyer and the maker, but, unfortunately, they did not always get that in practice. He had known consignments of steel worth tens of thousands of pounds condemned because one side found 0.034 and the other side found 0.029. In such cases tolerances did matter. He agreed, of course, as to the importance of the physical test. For the chemist to have freedom was all right from the chemist's point of view, but not from a commercial standpoint.

An amalgamation rumour has been circulated this week associating the names of Babcock & Wilcox, Limited, and Clayton & Shuttleworth, Limited. While the rumour has not been officially denied, Clayton & Shuttleworth, Limited, do not confirm it. It is understood that the offer of Babcock & Wilcox, Limited, only covers the interests represented by Clayton & Shuttleworth, Limited, and has no reference to Clayton Wagons, Limited.

The Council of the Institution of Production Engineers have co-opted the following members as council members:—Mr. H. A. Dudgeon, Coventry; Mr. H. S. Locker, Chiswick; Mr. Raymond Mitchell (Ransome & Marles Bearing Company, Limited, Newark-on-Trent); Mr. R. H. Hutchinson (D. Napier & Son, Limited, Acton); Mr. Zieshang (The Pyrene Company); and Mr. A. T. Davey, 6, James's Square, W.1. The following have been appointed to form a Development Sub-Committee:—Messrs. W. H. Dormer, W. Attwood, G. Hey, A. Butler, and A. T. Davey.

Wages of Cumberland iron-ore mines employés for the ensuing month are slightly increased, and will be as follows (per day or shift): Underground workers.—Miners' bargains, 10s. 2d. (1d. increase); miners' minimum, 7s. 6d. (1d. increase); underground first-class or leading labourers, 6s. 5½d. (½d. increase); other underground labourers, increase of ½d.; trailers' payment according to their respective categories. Surface workers.—Winding enginemen, 8s. 10½d. (¾d. increase); joiners, 9s. 2¼d. (½d. increase), plus 6d. tools allowance; chargemen and mineral shot borers, 9s. 2½d., plus 3d. per foot (½d. increase); blacksmiths, 9s. 2½d. (½d. increase); boys under 16 years of age, ½d. increase.

The annual meeting of the Newcastle Section of the Society of Chemical Industry was held at Armstrong College, on March 19, under the chairmanship of Mr. A. Trobridge, when the following officers were elected for the ensuing year: Chairman, Prof. W. N. Haworth, vice-chairman, Prof. H. V. A. Briscoe; treasurer, Mr. A. Trobridge; hon. sec., Mr. H. Dunford Smith; committee: Dr. P. E. Bowles, Dr. J. T. Dunn, Mr. D. W. Jones, Mr. Mordecai, Mr. F. H. Walker, Dr. W. Davidson, Mr. F. Hirsch, Prof. H. Louis, Mr. A. Short, and Dr. G. Weyman. Mr. W. G. Carey, who was to have given a paper on "East Durham Waters for Boiler and Other Purposes," was unable to be present, and accordingly Professor Briscoe gave an interesting talk on "Water Softness."

The Reduction of Iron from its Ores at Low Temperatures.

By J. Kent Smith, O.B.E.

At frequently recurrent intervals *direct steel processes*—that is to say, methods whereby it is claimed that steel may be produced directly by the reduction of iron ore—have achieved momentary notoriety, to disappear after a more or less brief occupation of that metaphorical limelight operated by irresponsible executants of non-technical journalism. Except in a strictly limited sense, and one that must always remain uncommercial in the conditions that have grown up at this date, many such carry their own refutation in their claims. The name *steel* does not designate one particular metal (pedantically it might be more correct to say one particular iron-alloy) of definite make-up, but rather a wide range of iron alloys; in other words, by our modern understanding, steel must be a *technically controlled* product. Steel made from iron ore must logically therefore always be at least a two-stage product. The modern steel industrial corporation cokes coal in its own coke ovens, smelts iron ore with this coke in its own blast furnaces, transfers this liquid metal to its own steel plant, and "soaks" the ingots resulting from this plant for their subsequent rolling in its own mills to finished products. It furnishes at the same time the major source of the power required in all these operations from the surplus gas and heat of its coke ovens, of its blast furnaces, and of its steel furnaces. In this light, therefore, it is operating a method of procedure which may be described as a *direct steel process* fully as legitimately as—for the sake of example—one which generates gas in a large gas-producer, super-heats it in its unburnt condition, and causes the sensible heat of this super-heated gas to melt and refine on some particular type of open-hearth metal which reaches it as a result of reduction, in a vertical shaft, of descending iron ore by means of the sensibly-cooler effluent gases of the hearth container.

Is Finality Represented by the Blast Furnace?

The real question at issue is consideration as to whether or not the blast furnace is the best means of reducing iron *when subsequent conversion into steel of the metallic product is the desired end.* The writer's deliberate opinion is that *in toto* such is not the case. It is in the highest degree unfortunate that so much confusion should exist between processes which are claimed to be "*direct*" *steel producers*, and those whose claims apply only to the *low-temperature or solid reduction* of metallic iron from its ores. Very many factors operate in establishing a conclusion as to the relative values of blast-furnace reduction and of *solid* reduction; it is the object of this article to particularise a few.

But first it must be definitely stated that the iron product of the blast furnace must and will always have an enormous sphere of utility in legitimate industrial requirements, and in any process of steel making involving the use of a gas-fired open-hearth furnace can it be dispensed with entirely. Obviously a pneumatic process of steel manufacture must work upon pig-iron or its exact equivalent, since the reactions required must be exothermic in their nature. In a steel-making process conducted upon an electrically-heated hearth or in the crucible, pig-iron is not required, and in the latter case is it indeed admissible, as to the main steel source.

The Product of the Blast Furnace.

The normal product of the blast furnace may be said to be grey pig-iron. This is an alloy consisting substantially of iron partially combined with—and possibly holding in solution—more or less silicon and phosphorus, the crystals of this solute forming an aggregate with sulphide of manganese, phosphide of iron, etc., and the whole being freely interspersed with particles of an elementary form of carbon, *i.e.*, graphite. The metal has a relatively-low tensile strength, and little or no ductility. Its very defects, however, confer upon it physical virtues, for it melts readily and casts soundly, in both of which respects it differs markedly from pure iron or steel. Hence for those articles with whose production we associate the iron foundry, a product such as pig-iron is, and always will be, essential. In any process calling for the melting of iron by direct exposure to the products of combustion, especially should those products be "oxidising" in relation to iron, should or can pig-iron be dispensed with. Pig-iron has a highly solvent action on more or less pure iron, in which latter category are included steel scrap and the granular product of low-temperature reduction.

In other words, the product of the blast furnace can only be replaced *in toto* as the result of some method of procedure which reproduces at a lower cost the temperature conditions and the internal environments incidental to that highly perfected and useful piece of apparatus. No process of "low-temperature" reduction can possibly do this, and therefore pig-iron which is to be used legitimately *as* pig-iron, will and must remain with us, as a blast-furnace product probably for many generations.

A glance, however, at the iron statistics of the world will show, at least by interpolation, how immense is the proportion of the blast-furnace product which is used as a steel intermediate. And, as regards the immense majority of this pig-iron—translating the expression quite inoffensively—may be described as a very clumsy intermediate. It is in respect to such proportion of the steel production of the world that low-temperature iron-ore reduction products legitimately find their usefulness, for, properly applied in such sphere, they can be the means of reducing the cost, and simultaneously increasing the quality, of the world's steel supply.

It has been said by irresponsible persons, or at any rate by persons who must combine the possession of somewhat remarkable mentalities with restricted view points, that the main stumbling block of processes of direct or low-temperature reduction must be their clashing with the vested interests of those concerned in blast-furnace practice. The exact converse is really the case. One of the biggest bugbears of the blast furnace is dead-fine ore; and it is dead-fine material which is required for the successful operation of a low-temperature process. Therefore, instead of such a system as the latter clashing with the interests of the blast furnace, it must be looked upon as a most valuable auxiliary to it. The real stumbling block to the world-wide practice of "solid" reduction of iron ore—which in essence is itself almost as old as the hills and formed the basis of the world's iron supplies for many centuries—has rather lain in the fact that, up to quite recently, the mechanical requirements necessary for its practice (at cost and in quantity commensurate with present-day requirements and processes) have been lacking.

Before attempting to outline the economic advantages which are offered by a system of the "low-temperature" reduction of iron in general, it may be well briefly to consider the consumption and distribution of the heat-forming agents fed into a modern blast furnace. Subsequent piecemeal comparison will thus be rendered possible.

Energy Distribution.

This piece of apparatus must be looked upon partly as an instrument in which the heat-forming agents are used up chemically or thermo-chemically in reducing, melting and super-heating metal and slag, and partly as a huge producer of gases with further potential energy. In average modern conditions the respective quantities of the fuel charge thus apportioned may be said to be half and half. True, the majority of such potential energy is utilised (after its conversion into heat and power by means of "stoves," gas engines and steam boilers) for the running requirements of the

furnace; there is, however, in good practice always a surplus of this potential energy.

What the Blast Furnace Accomplishes.

The furnace itself may be described as a vertical shaft, terminating at its bottom end in a closed container or well for the reception of molten metal and slag; immediately above such well there are introduced peripherally continuous currents of heated air under considerable pressure. At the upper and readily accessible end are introduced, at frequent intervals, charges primarily composed of (*a*) the iron-bearing mineral to be reduced (almost invariably the oxide, possibly in its hydrated or carbonated form); (*b*) the fluxing mineral (almost invariably limestone, sometimes in up-to-date practice accompanied with a little fluor spar); and (*c*) fuel (generally in the form of dense, hard, metallurgical coke, much more rarely in the form of wood-charcoal, and in some districts even in the form of hard, splint-coal). As this mixed charge descends through the shaft, chemical re-arrangement takes place; the final products are melted in the hottest zone of the furnace and collect in the well, whence they are removed in their molten condition at frequent intervals. Space is thus provided for the introduction of more charge.

Functioning of the Furnace.

Near the bottom of the furnace where the hot air entering meets with the by-now incandescent fuel portion of the charge, the fuel is gasified, partially or entirely, the resulting gases consisting essentially of carbon monoxide and of diluent nitrogen.

The iron oxide of the ore is reduced to metal, largely by the action of the carbon monoxide of the gas, and partly by the interaction of a portion of the solid (and as yet unconsumed) carbon of the charge and the oxide of iron. The former action is exo-thermic; both reactions are easily reversible. Since the reducing action of carbon monoxide upon iron oxide begins at a temperature as low at 300 deg. C., and is fairly complete at temperatures little exceeding 800 deg. C., most of the actual reduction of the oxide of iron in a blast furnace is obviously done in a reasonably high zone in the furnace. With reference to such portion of the metal-bearing charge as is reduced directly by contact with elementary carbon, this reaction, unlike the first-named, is strongly endothermic, or, in other words, it requires considerable quantities of extraneous heat. It does not begin at such low temperatures, nor is it completed quite as low, as in the first considered case.

The reduced spongey iron becomes impregnated with carbon, partly as the result of the catalytic decomposition of carbon monoxide and partly by direct absorption of that element. Carburation may begin at the comparatively low temperature of the reducing zone, and continues through the hotter zones.

A portion of the silica content of the mineral is reduced by solid carbon at the high temperature prevailing in the lower zones of the shaft; the reduced silicon dissolves and subsequently reacts with the carbide of iron formed as above described, precipitating the carbon partially or almost entirely in the amorphous or graphitic form, and replacing it in the iron solution itself.

Some of the phosphorus content of the material is likewise reduced by solid carbon at or about the same point, the reduced phosphorus partly dissolving in the iron, and partly forming an iron-phosphorus eutectic according to the circumstances of the case.

Calcium and other carbonates are decomposed in those upper zones in which, at any rate, a large part of the iron reduction takes place, giving lime and carbon dioxide.

Lime resulting from this decomposition fluxes with the gangue of the ore and with the ash of the fuel at those high temperatures prevailing in the lower zones of the furnace forming slag.

All the solid contents of the shaft—that is to say, the whole of the materials entering it, less such portion of them as has been gasified or vaporised—are, after having undergone decompositions and re-arrangements as indicated, brought to a state of fusion in the hottest zones of the furnace, leaving either as fluid metal or fluid slag via the tap hole.

Low Temperature Reduction Plant.

A plant for the low-temperature reduction of iron consists essentially of three rotary cylinders, the first for pre-heating the charge, the second for reducing it, and the third for cooling it in a non-oxidising atmosphere. The cylinders are connected to each other by means of efficient sealing devices, as also with the terminal arrangements for ingress and egress of the mineral and its various products. The second or reducing cylinder is "fired" by the products of partial combustion of pulverised slack. The iron-bearing mineral is fed to the apparatus in finely divided form; the mixed (granular) metallic and gangue products of reduction after cooling are separated by electro-magnetic or other well-known mechanical means.

Obviously low-temperature reduction renders possible considerable saving of fuel. Necessarily, fuel consumption reckoned on a ton of pig-iron must vary considerably both in its total amount and in its distribution according to the mineral from which that pig-iron is made. Some observed average conditions, where a grade of ore containing approximately 50 per cent. of iron formed the main raw material; where limestone in the equivalent of about 25 per cent. of the ore was added concurrently with it for fluxing purposes, and where the *net* consumption of fuel was approximately 20 cwt. per ton of iron made will be considered. In this last connection the observed surplus heating gas over and above that required for the stoves, blowing engine, etc., has been deducted from the total amount of fuel fed into the furnace.

Heat Balance Considerations.

As previously, the writer will confine his attention only to the major reactions and distributions. Minor reactions, almost negligible in themselves as affecting heat balances, occur, however, which may most profoundly affect the quality of the metallic product of the furnace. One of the most important of such shall be alluded to later. In the "raw material" conditions noted above—of the net total amount of heat-forming agents supplied to the furnace, slightly more than half was used up in the furnace itself in heating, reducing and melting the final product and in supplying those needs due to the thermal inefficiency of the container.

Of this amount, at least two-fifths was consumed chemically and thermally in the actual reduction of the iron oxide. The reduction takes place along two routes; on the first of these carbon monoxide is the reducing agent, the final oxidation of this partially oxidised carbon compound being completed at the expense of the oxygen combined with the iron in the ore. This reduction reaction, be it noted, is slightly exo-thermic. On the second route reduction of iron oxide is accomplished by means of its direct interaction with elementary carbon, which reaction is strongly endothermic. Unfortunately, in the first case the simple equation FeO plus CO equals Fe plus CO_2, quite independent of its reversibility, is not a balanced reaction. Carbon dioxide acts as a very powerful deterrent to the reducing effect of carbon monoxide on iron oxide; when the carbon dioxide equals in quantity the carbon monoxide present the reducing action of the latter on oxide of iron virtually ceases. Long before this point is reached its reducing action is greatly retarded. Careful investigation of a thorough average of blast-furnace practice to-day will reveal the fact that in the thermal conditions of the process the amount of carbon dioxide present in the exit gases is accompanied by no less than one and a half times its own bulk of carbon monoxide. Therefore in respect to the carbon dioxide produced as the ultimate gaseous product of actual reduction we find ourselves under dictation by a natural law of equilibrium which no form of apparatus designed by man can legitimately be expected to modify. But the carbon dioxide in blast-furnace gases partially comes from sources other than the gaseous products of reduction. In the average case in question, as in all blast-furnace practice more or less, there is a large amount of carbon dioxide coming from the decomposition of the limestone. This is liberated in those zones of the furnace in which the reduction of iron oxide by carbon monoxide is taking place.

In the low-temperature reduction of iron no limestone or other carbonate is added. Therefore less potential heat is carried away in the exit gases, which gases, nevertheless, still remain in quantity sufficient for all power requirements of the plant, which, it should be noted, requires no hot blast.

Direct reduction by elementary carbon clearly requires, therefore, much less of the element than if it be first converted into carbon monoxide. In blast-furnace practice, such as has been cited, roughly 20 per cent. of the iron product is reduced by elementary carbon and 80 per cent. of it by carbon monoxide. If the reaction can be driven further in the direction of elementary reduction, the quantity of carbon used up would naturally be less than the total observed, but here thermal requirements come into play. In the case of low-temperature reduction in a rotary furnace reduction by elementary carbon will be even less than in the blast furnace. Full allowance, however, is made for this in the summarised results.

An appreciable proportion of carbon, which may amount to well over 5 per cent. of the fuel used up in the furnace, dissolves, as has been shown, in the molten iron, whereas the amount of carbon entering into combination with iron produced in the practice of low-temperature reduction is so much less as to be practically negligible.

A little carbon is used up in reducing silicon from the gangue of the ore. This silicon—as has already been said—dissolves in the iron, and at or about the point of setting precipitates the majority of carbon up to now in true solution. A further small amount of carbon is used up in the high-temperature reduction of the phosphates. There is practically no consumption of carbon under either of these heads in a properly practised low-temperature reduction process.

Nearly one-fifth of the total heat usefully consumed is utilised in the heating of the metal and slag products of the blast furnace; in low temperature reduction the amount of heat carried away by solid products is rather less than one-third of this amount.

In the blast furnace the amount of heat required for the expulsion of the carbonates in the limestone of the charge accounts for close upon 5 per cent. of the heat in the fuel used up in the furnace; in low-temperature reduction this charge upon the heat supply is completely absent.

Heat losses due to water cooling and to radiation account for close on one-fifth of the fuel utilised in the blast furnace. Obviously this source of loss is much minimised in low-temperature reduction work since temperature differences are so much less and little or no cooling water is required.

Driving off water from the charge and decomposition of moisture contained in the air supply would approximately account for a consumption of heat equal in both cases.

Conclusions as to Economics.

Careful observations and calculations made by the writer determine the *quantity* of fuel saved in low-temperature reduction as 25 per cent. of the total nett amount supplied to a blast furnace for the production of equal quantities of iron. The possible saving of this *amount* of fuel may seem a comparatively small objective; the real importance lies in the fact that one ton of high-grade and comparatively expensive metallurgical coke used in the blast furnace can be replaced by the use af 15 cwts. of comparatively cheap low-grade slack in the low-temperature reduction process. As a result the financial economy under the fuel head alone is very considerable indeed. But, still adhering only to questions of financial economy, the low-temperature process has very many other points of recommendation. The plant is relatively inexpensive in first cost and in upkeep as compared with a blast-furnace installation of the same capacity; its labour and upkeep requirements are relatively much smaller, and it can be started and stopped infinitely more quickly and more cheaply than can the blast furnace.

From the points of view of cost and convenience, therefore, the low-temperature reduction of iron ore offers great attraction. But the benefit of its adoption does not end here by any means; speed of refining of its product renders the proposition still more attractive. And last, and most important of all, the excellent inherent physical properties of the final resultant overwhelmingly strengthen the attraction.

Nitrogenisation is Absent.

The major reactions occurring in the blast-furnace smelting of iron ore have previously been dealt with only, but it has already been stated that minor reactions, profoundly affecting quality, take place in the blast furnace. Not the least of these is nitrogenisation. The writer definitely states that nitrogen in steel is one of its worst enemies, and affects very materially the embrittling effect of phosphorus and the "redshort" effect of sulphur.

Elementary nitrogen cannot react upon and enter into combination with iron, otherwise no good steel or iron could be made by any process practised to-day. Nitrogen enters into combination with iron via the *cyanogen reaction* which takes place in the hottest zone of the blast furnace. If something more avid for this nitrogen compound than is iron be concurrently presented to it, the iron itself will be low in nitride content, and this is precisely what happens in Swedish blast-furnace practice. If the nitrogen has been allowed to enter the pig, as in British or American practice, it can be removed (to equilibrium proportion) by treating the pig-iron or its resultant steel product by vanadium. The vast improvements following simply upon the denitrogenisation of iron or steel are too well known and too abundantly recorded to need reiteration here. In low-temperature reduction heat-intensity never approaches anything like the point necessary to bring about the cyanogen reaction, and the resultant granular iron from it is therefore practically nitrogen free.

The writer was enabled recently to convert some tons of the granular product of low-temperature iron ore reduction to steels of various types, and the results are very strikingly confirmative of the inherent toughness of the iron base. The low-temperature product had been made from a low-grade of English ironstone, and had been indifferently mechanically separated from its phosphoric and sulphury gangue. A *plain* (0.35 per cent.) carbon steel of very ordinary *analysis* was obtained containing sulphur and phosphorus in the amounts of 0.07 and 0.05 per cent. respectively. It is indicative of the whole series that a static test such as the following was obtained from its bar (1½ in. dia.) after heat treatment:—Yield point, 34.5 tons per sq. in.; maximum stress, 44.6 tons per sq. in.; elongation, 27.5 per cent.; and reduction of area at fracture, 61.6 per cent.

This was accompanied by dynamic attributes represented by the following figures:—Izod impact test, 99 foot lbs.; Stanton test, 1,612 blows; rotary fatigue, 164,400 revs. (100,000 at 20 tons fibre stress, followed by 50,000 at 25 tons fibre stress, and finishing with 14,400 at 30 tons fibre stress).

This is surely a very fine combination for any "straight-carbon" steel, let alone for one of *very ordinary analysis*.

The low-temperature reduction of iron will most undoubtedly play a very important *rôle* in the industrial metallurgical developments of the next few years. To give a few of the reasons for making this definite pronouncement has been the author's aim in this article.

Large Steel Pipe Contract for India.—An important contract has been secured by the British Mannesmann Tube Company, Limited, Newport, Mon., for the supply of welded and riveted steel pipes in connection with the Tata Power Company's new hydro-electric scheme in India. The project, known as the Nila-Mula, or Bhira Scheme, is the third and greatest of the Tata enterprises for conserving and harnessing the storm water of the Western Ghats and conveying it by pipelines to the hydro-electric plant. The current is conveyed by overhead transmission at a pressure of 110,000 volts to Bombay, some 80 miles distant, where it is transformed down for the use of the mills, factories, tramways, railways and other undertakings. The order for pipes is the biggest for a hydro-electric scheme ever placed in Great Britain, the approximate total weight of the pipes and specials being about 9,000 tons.

Institute of British Foundrymen.

SHEFFIELD BRANCH.

Discussion on Mr. Harley's Paper on Metallurgical Control in Automobile Foundry Practice.

The discussion was opened by Mr. Bradley, who confirmed the author's views on the relative values of the electric and converter steel making plants. He had experienced no difficulty from the electric furnace in general, but in this connection one had to consider the capacity of the furnace in relationship to the number of moulds to be cast. He found that running from a 40-cwt. converter was equivalent to casting from a 30-cwt. electric furnace.

Electric Steel Castings Criticised.

Mr. Hyde said he thought the lecturer's remarks were very interesting in regard to converter and electric steel. They had used an electric furnace for three or four years and put in considerable time and experiment in order to get reasonably good results from it, and succeeded. Owing to prices they had introduced a converter, and had no further use for the electric furnace to-day. In regard to melting in the electric furnace, they melted the steel and tapped it dead. In the converter they tapped an oxidised bath, and while the silicon was acting there was more fluidity. He was not surprised at hematite being favoured for cylinder barrels, for it had been found it gave just as good wearing properties as the harder iron. It should be remembered there was 4 per cent. of graphite present, which was a good lubricant.

Mr. Darley, referring to the relative merits of the converter and the electric furnace plants, said his firm had installed both, but they had scrapped the Stock converter. During the time the Stock furnace was running, they could make castings as thin as from $\frac{1}{8}$-in. section. They now used the electric, but they occasionally met with serious trouble with gas holes on the bottom side of the mould, due to the sluggishness of the metal. He had found that in the electric furnace, when the impurities were largely reduced, that there was no "life" in it, and that the metal would not run very far. Further, in his opinion, one of the chief causes was on account of the low phosphorus. They had increased the phosphorus by adding phosphorus, and they had obtained a very much better casting. He gave the example of marine pistons. Towards the outer edge the casting invariably showed gas holes which became more oval in form towards the extreme edge. Their research department had taken up the matter, and it had come to the conclusion that on account of the steel not being sufficiently fluid, gas became trapped, and there was not sufficient fluid to drive it out. Speaking with reference to the road wheel, which the lecturer had shown, he asked whether one had ever been cut up from the boss? He thought it would be found that when they chilled a casting on the outside it invariably pulled the joints of the chill. In conclusion, he would like to know where the lecturer could obtain the sand so near to Sheffield.

Pouring Conditions.

Mr. Rhydderch said that the lecturer had not dealt with the method of pouring steel castings. Opinions were sharply divided on the relative merits of bottom pouring and shanking. It would be interesting to learn the speaker's experience on this point. Personally, he favoured shanking for the production of light steel castings for soundness and solidity, and lip pouring for the very large castings, leaving bottom pouring to the medium-sized castings.

Another point was the shrinkage of steel. Had the speaker noticed any difference in the behaviour of the shrinkage of electric and converter steel, especially with a widely varying phosphorous content? A friend of his had emphatically stated that shrinkholes were very much more pronounced with a phosphorous content of over 0.03 per cent., than if below this limit. Of course, this refers to mild carbon steel castings. Personally he had no experience in this matter on which to have an opinion.

It is a well known fact that slightly oxidised steel does not shrink nearly as much as dead melted steel, and over-oxidised steel "rises."

Fluidity of Steel.

The point has been raised by the lecturer and other speakers of the fluidity of electric steel. Judging from one example of carbon, less than 0.1 per cent., and a very low manganese and silicon, it would be difficult to get high fluidity. Generally speaking, increased fluidity with medium C steels can be obtained by using much higher manganese—say 1.2-1.4 per cent., and higher silicons—say up to 0.8 per cent. Further, a theory has been put forward that tapping on a slightly oxidised slag also gives greater "life" or fluidity to electric steel. There is nothing against this theory because there is a similar instance in the behaviour of electrolytes on colloids.

Skin on Castings.

The question of a skin on castings had also been raised. This generally happens with naturally bonded sands, in which the bonds are generally of a very low fusion point, and easily form slags as a result, but it is not considered to be useful for the larger castings. In fact, large castings that strip well often show unsoundness on machining, probably due to the excessive formation of this viscous layer. If this factor is investigated in detail, and reacting elements put under careful control, it might be possible with the heavier castings.

Dealing with the accuracy in the size of castings, cored faces, etc., it would be interesting to know to what limits the lecturer could work on routine steel castings for motor car work.

Mr. Edginton said before he contributed anything to the discussion, he would like to ask how to get pure hematite iron. Speaking of the trouble with machine shop castings, he was inclined to agree that if they were more particular there, the foundry would be saved much trouble, and there would be a saving in many ways. The machine shop did not give enough thought to the "set up." He would like to mention that he had put an electric furnace down and he had had to win his knowledge by experience. When first they started making steel castings the manganese content was about 0.4 per cent., with the result that they got pin holes on the bottom of castings. But when they raised the manganese content to about 0.9 per cent., they eliminated a great deal of that trouble.

Mr. Robinson referred to the amount of phosphorus in cylinder irons, and the regulations fixed by the Ministry during the war that 0.8 per cent. of phosphorus was the more satisfactory amount for such a casting. It would seem, he said, that below 0.3 per cent. of phosphorus and above 0.8 per cent. one stood a better chance of getting a sound casting than between those limits. At a lecture given by Mr. Cook, at Birmingham, the same opinion was expressed, and it was stated that cylinders cracked on the piston valves with a low percentage of phosphorus. By increasing the phosphorus this was eliminated. That was somewhat opposed to what they generally understood. At the same time, it was believed one could get a sounder casting by doing it. Speaking of the tensile and transverse tests, he believed a good test was the shock test. During the time they were making experiments on material for a certain type of steel shell, they instituted a shock test which proved very helpful. As to using softer material for cylinders, they found that softer material gave a longer life. He did not think it was due to the lubricant of the graphite and when using high-carbon iron a certain amount of the free graphite worked up on to the face and caused it to harden on the carbon face. In machining the casting, all their pistons, either large or small, directly they went from the foundry to the machine shop they were roughly machined and then annealed. In regard to aluminium, he always had better results from chills than from feeders.

* This Paper appeared in our issues of March 13 and 20.

XUM

Mr. Green said the higher the total carbon the greater the fluidity. That, apart from the property of withstanding wear produced by the lubricating action of the graphite, there seemed to be a structure on the micro-section shown, in which the pearlite predominated, and this, no doubt, helped in that direction.

To obtain this structure, it is necessary to obtain a proper combination of elements and also the correct rate of cooling.

Value of Pearlitic Structure.

Mr. J. Shaw (Chairman) said during his term of office he did not generally take part in the discussions, but he could not let pass the statement made by Mr. Harley with reference to high total carbon. Whilst for the thin work on which Mr. Harley was engaged it might even be beneficial; he had no hesitation in stating that in heavier sections it was harmful. He also agreed with Mr. Green that a true pearlitic structure was the one to be aimed for, both from the strength and machining point of view. The great difficulty was, under cupola practice, to hit the right composition. The speaker had once cast a tyre-roll that gave such remarkable life and lack of wear that a thorough investigation was made. This roll gave 2,227 tyres without redressing; the ordinary life being about 300. Nothing was found in the mixture but what had often been used before, but in this case the pearlitic structure had been developed by some means difficult to trace.

The Author's Reply.

The Lecturer, in reply, said he had realised that a very much different set of conditions existed in Sheffield as compared with his own. The heaviest steel casting he made weighed three cwts., and when examples were given about big moulds—he believed 20 ft. had been mentioned—he was afraid he did not know very much about it. With regard to the quality of Stock converter steel and electric steel, he would like to make it clear that at the back of his mind he felt that if he paid enough attention to electric steel he could get steel as good, if not better, than Stock converter steel. From the same moulds, prepared in the same way, he could make sound castings with converter steel, and he obtained more often porosity in electric steel. If he could overcome the trouble of fluidity, he could look after the other difficulties quite easily. But one of the principal reasons for not using the electric furnace was the fact that the cost of current was so high and was a handicap in competition. If it was reduced he would use the electric furnace. From what he had learned, he believed that the steel absorbed some of the aluminium and there was reaction with some of the gases coming from the mould. There was something mysterious in the action of electric steel. Road wheel castings were never annealed. He believed in annealing as a general principle, but in road wheels they had not found it necessary, as they had never had one returned. The steel, as cast, was perhaps more rigid than annealed steel, and the action of the road wheel was such that it supported it better. With regard to the accuracy of the casting, he thought a good section was not indicative of a good casting, but at the same time that should not prevent them from getting a good section as well as a sound casting. Accuracy of the casting depended on what the casting was, but he thought they could make cylinders starting from any point, because they knew where they were starting from. On work of urgency they could work to ½ mm.

He was not claiming any advantage for high total-carbon iron. In making a casting they had to consider more closely the service that casting had to stand, the machine shop and the cost of machining, but what he did claim was that in auto-cylinders he did not need to reduce the total carbon. He knew it was only 10 tons tensile, but it was sufficiently strong. He had made more castings to withstand piston wear than anyone in England. He had listened to the suggestions on pearlitic structure, and he believed they would have to have metals of special composition where the range of fluidity was lessened. He advocated more purity in cast iron. If he had to use phosphorus, he would prefer it to be slightly above one per cent. Why it was he did not really know, but he had noticed that it was particularly persistent in quantities between 0.8 and 0.3 per cent., and the reverse up to one per cent. In regard to tests, he did not consider the tensile and transverse tests were sufficient. They required another test which would register the difference between various grades of cast irons.

Personal.

The Right Hon. The Viscount Pirrie, K.P., chairman of Harland & Wolff, Limited, left Southampton recently for a visit to South America.

Mr. W. G. Phillips, the operating assistant to the chief docks manager of the Great Western Railway, is retiring. Mr. Phillips was closely associated with Mr. Vickery at the Alexandra Docks, Newport, before going to Cardiff on the amalgamation of the South Wales Docks and Railway Companies with the Great Western.

Mr. Harry J. Kelly, for thirty-three years general superintendent of the Bethlehem Steel Works, has been appointed general manager of the steel plants of the British Empire Steel Corporation in Nova Scotia. He will have charge of all the steel operations of the Corporation. Mr. N. J. McCann is in charge of all colliery operations, and Mr. J. E. McLurg is vice-president.

Miss Girvin (the only daughter of the late chairman) has joined the board of Robt. Girvin & Company, Limited, Exchange Chambers, 24, St. Mary Axe, London, E.C.3. Mr. H. R. S. Graves, who has been for so long actively associated with the firm, has been elected chairman of the company, and will continue to direct its policy as joint managing director with Sir William John Jones, who has also joined the board. Mr. G. V. Parker has resigned.

Wills.

Fletcher, H. M., of Fletcher, Son & Fearnall, Limited	£55,028
Brooke, J. W., chairman of J. W. Brooke and Company, Limited, engineers, etc., Lowestoft	£26,587
Hutton, J., of Polwarth Terrace, Edinburgh, chairman and managing director of Alder & Mackay, Limited	£16,784
Nevill, F. R., J.P., managing director of Richard Nevill & Company, Limited, Wern Ironworks, Llanelly, and the Gowerton Engineering Works, Gowerton	£10,664

Obituary.

Mr. R. Edmund Froude, for forty years superintendent of the Admiralty Experimental Works at Torquay and Gosport, has died at Cambridge, at the age of seventy-eight.

Mr. Frank James, of Penkridge, who for many years was a prominent figure in the public life of Staffordshire, died on March 23 in his 103rd year. Mr. James was a native of Walsall. He received his education at Handsworth, Birmingham, and King's College, London, and subsequently joined his father in business associations with Walsall, being connected with the James Foundry Company.

Legal Intelligence.

Bolckow, Vaughan and Company *v.* The Crown.

In the Court of Appeal, last week, before Lords Justices Bankes, Warrington, and Atkin, Bolckow, Vaughan & Company, Limited, of Middlesbrough, appealed from the judgment of Mr. Justice Rowlatt dismissing, with costs, their petition of right against the Crown.

The petition was based upon an agreement, dated March, 1916, between the company and the Ministry of Munitions, whereby the latter agreed to pay 75 per cent. of the cost involved in making an extension of the company's steelworks. It was contended that the contribution was to be paid by the Ministry in the form of the remission of moneys payable by way of munitions levy to the Government, and also in the form of an allowance in respect of additional output. The extension had cost over £700,000, and the company complained that they had received nothing under the agreement.

For the Crown it was argued that sufficient had been allowed to the suppliants by way of munitions levy and excess profits duty to satisfy the claim.

Mr. Justice Rowlatt held that the disappearance of the munitions levy, as such, removed the very fund from which the payment was to have been made by the Crown, and that the petition failed for the want of subject matter. Hence the present appeal.

Their Lordships reserved judgment.

Trade Talk.

Brolt, Limited, have disposed of their Princess Street Works in Birmingham.

A new benzol plant at the Ebbw Vale Works was damaged by fire on March 20.

Ropeways, Limited, have removed their London offices to Aldwych House, Aldwych, London, W.C.2.

Owing to trade depression caused by trade disputes, 1,000 men have been thrown out of work at Barrow.

A fire seriously damaged the nut and bolt shop of the Anderston Foundry Company's Port Clarence works on March 19.

Ruston & Hornsby, Limited, Lincoln, have removed their London office to Imperial House, 15-17-19, Kingsway, London, W.C.2.

A fire broke out last week at the works of Messrs. Kynoch's, Witton, Birmingham. The fire was extinguished before much damage was done.

Considerable damage was caused by fire to a wooden building at the London and North-Eastern Railway wagon works, at York, on March 21.

The British Steel Piling Company, Limited, have removed from Dock House, Billiter Street, E.C., to 54a Parliament Street, Westminster, London, S.W.1.

The South Wales and Lincolnshire Steel Products, Limited, Caxton House, Westminster, S.W.1, have removed their head office to Bush House (3rd floor), Aldwych, W.C.2.

Hook & Willis, Limited, 74, Goding Street, Vauxhall, London, S.E.11, have been appointed representatives for Trevelyan (Birmingham), Limited, electrical engineers, of 155, Bracebridge Street, Birmingham.

Mr. C. E. Douglas, who resigned his position as a director of Douglas & Grant, Limited, towards the end of last year, has established himself in business as an engineer at 34 St. James Street, Bedford Row, London, W.C.1.

The Bon-Accord Engineering Company, Limited, Wailes Dove Bitumastic, Limited, Redler Patents, and the Universal Die Casting and Metal Company, Limited, have been elected members of the Federation of British Industries.

Harland and Wolff, Limited, have decided to undertake constructional steel work, in addition to shipbuilding and marine engineering at their Scotstoun Works, Glasgow. The company are also supplying castings from their foundry at Govan.

Licences under the Non-Ferrous Metal Industry Act, 1918, have been granted by the Board of Trade to Morgan, Grenfell & Company, 22, Old Broad Street, London, E.C.2; Sir S. W. Royse & Company, Limited, 20, Albert Square, Manchester; and Elizabeth Hodgkins, trading as E. Hodgkins & Company, Cromwell Street, Birmingham.

Prince Smith & Son, textile machinery makers, ironfounders, etc., Burlington Shed, Lawkholme and Strong Close Works, Keighley, have acquired the premises formerly occupied by the Dickinson Machine Tool Company, Limited, Devonshire Works, Pitt Street, Keighley. They will use these works as an extension to their spindle department.

The Committee of the Birmingham Metal Exchange is warning members that brass swarf containing a considerable proportion of sand is again being offered. Two samples recently tested contained 38.8 per cent. and 21.4 per cent. respectively. This admixture of sand is very difficult to detect by inspection, even when a microscope is used. Samples should always be analysed before a purchase is made.

The loss incurred by Henry Bessemer & Company, Limited, during the past year was mainly at the Bolton works during the first six months of the year. Their policy is to gradually close down these works, and make improvements and additions at the Sheffield works. The freehold of the Sheffield works, and water rights, have been purchased. They were formerly held under leases expiring in about 30 years.

The Horsley Bridge & Engineering Company, Limited, Dudley Port, Tipton, Staffs, announce that, owing to ill-health, Mr. H. J. Batting, who has represented them in London for 40 years, is retiring from his appointment on March 31. Mr. L. Harper, who has been in the company's employ for several years, and has for some time been acting as assistant to Mr. Batting, has been appointed to fill the position, and he will conduct the company's affairs in London as from April 1.

The prospectus has been published of Grigg (1924), Limited, formed to take over a business of the same name manufacturing motor-cycles, power units, gears, etc. The capital is £150,000 in £1 shares, and the present issue is of 84,220 shares at par, the remainder being part of the purchase-price. The assets to be acquired are valued in the prospectus at £92,387. This sum will be satisfied as to £26,607 in cash and as to £65,780 by the issue of fully-paid shares in the new company. The present issue is expected to give £45,613 for working capital.

At the Swansea Metal Exchange a meeting recently took place of the joint standing committee in connection with the newly-constituted Conciliation Board in the Welsh steel trade. Mr. F. W. Gilbertson (president, South Wales Siemens Steel Association) presided. At the first meeting of the newly-constituted board this joint standing committee was appointed to exercise important functions between the meetings of the full Conciliation Board, and to this committee was referred three subjects for consideration, viz., the question of third hands in acid-melting shops, flowing and bottoming rules in melting shops, and a difference respecting the interpretation of the piece-work arrangement affecting steam and electric service men. The meeting, which was private, discussed these subjects for the purpose of reporting to the Conciliation Board.

The Industrial Court has issued its award on claims for advances in wages from 40s. to 41s. a week in the basic rate for joiners, plumbers, bricklayers, and masons, and from 39s. to 41s. a week in the basic rate of painters employed in H.M. Dockyards and Admiralty establishments. The Court decided that joiners, plumbers, bricklayers, and masons who, by their apprenticeship or long training, have become fully qualified in their respective trades, shall when engaged on craftsmen's work be included within the group of occupations rated at a basic rate of 41s. per week; and painters who, by their apprenticeship or long training, have become fully qualified in their trade, shall when engaged on craftsmen's work be placed on a basic rate of 40s. per week. These rates are exclusive of the war advance, at present amounting to 17s. per week.

A scheme of arrangement is to be placed before the shareholders of the Agricultural and General Engineers, Limited, at meetings to be held on April 15. The proposals to be submitted are the reduction of the present capital from £8,000,000 in 8 per cent. and 6 per cent. preference shares and ordinary shares, all of £1 denomination, to £6,757,184, by cancelling 10s. per share on the issued ordinary shares. The unissued ordinary shares are to be split, each into two shares of 10s. denomination. The arrears of preference dividend due to the holders of the two classes of preference shares are to be satisfied by the issue to the holders of the 8 per cent. preference shares of one ordinary share of 10s. fully paid for every three of such preference shares held, while the 6 per cent. preference shareholders will receive one 10s. ordinary share fully paid for every nine of such preference shares held.

According to the 48th annual report of the Midland Iron and Steel Wages Board, there are 83 firms subscribing to the Board. The last report showed the rate for puddling from December 2, 1922, to February 3, 1923, at 13s. 6d. per ton plus 42½ per cent., and from that period the following settlements have been made:—February 3 to April 7, plus 40 per cent.; April 7 to June 2, plus 42½ per cent.; June 2 to August 4, plus 50 per cent.; August 4 to October 6, plus 57½ per cent.; October 6 to December 1, plus 57½ per cent.; December 1 to February 2, 1924, plus 55 per cent. Matters affecting the works of John Bagnall & Sons, Limited, and Robert Heath & Low Moor, Limited, were considered. Mr. W. R. Lysaght has again been elected the representative of the Employers' Section of the Sheet Trade Committee on the Standing Committee, with power to Mr. D. C. Lysaght to act in his absence, and Mr. J. Fisher will represent the Workmen's Section. The total receipts for the year have been £5,470, the expenditure £4,620, and the bank credit balance is £551.

Stein and Atkinson, Limited, 47, Victoria Street, Westminster, S.W.1, have recently received a number of orders for Chapman agitators, amongst which are the following:—Seven agitators for Jas. Dunlop and Company, Limited, Calder Bank; 3 for the Steel Company of Scotland, Limited, Blochairn; 2 for the North British Locomotive Company, Limited, Glasgow, and 2 for Geo. Davidson and Company, Limited, Gateshead-on-Tyne. In addition to the above, Stein and Atkinson, Limited, have also received orders from Geo. Davidson and Company, Limited, for a completely mechanical gas producer. Other orders received include a continuous annealing furnace for cast-iron pipes for the Stanton Ironworks Company, Limited; a spring annealing and tempering furnace with combined gas producer for Willford and Company, Limited, Sheffield; a 12-pot glass melting furnace with gas tubing and "Modern" tile chimney for Geo. Davidson and Company, Limited, Gateshead-on-Tyne, and a similar furnace with gas producer, gas tubing, and "Modern" tile chimney for Sowerby's Ellison Glassworks, Limited, Gateshead-on-Tyne.

XUM

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—It is satisfactory to note that, contrary to general expectation, conditions in the Cleveland iron trade have taken a distinctly better turn during the past week, and this especially in foundry qualities, purchases of which in the period under review having largely exceeded in the aggregate the entire total for the past month. It is now becoming evident to buyers that the limits of concessions in values have been reached, and in consequence the heavy stocks accumulated in makers' yards are steadily diminishing, both on home and export account. In the latter section of the trade the improvement in tonnage shipped abroad may doubtless be attributed to the recent movements on the Continental exchanges. The recovery of the French and Belgian francs has stimulated demand to a certain extent for Tees-side products abroad. At the present time there are some heavy orders pending for Cleveland iron on account of large contracts placed with engineering, constructional and shipbuilding works, which, granted an extended period of industrial peace, would greatly benefit the industry, but these are, unfortunately, held up by the prevailing uncertainty as to the result of the coal miners' decision in the dispute now under negotiation. Recently some large parcels of the standard No. 3 G.M.B. had been sold at as low as 90s. per ton, but at this week's market the general quotation was about 95s., and there were indications of a further stiffening of prices. No. 1 was about 100s., No. 4 foundry 94s., and No. 4 forge 93s. per ton.

The hematite position is, on the whole, a little stronger, and producers are taking a more hopeful view of the outlook. In the export trade there is certainly a more active inquiry, and a fair amount of business has been put through. During the past few days a firmer tone has prevailed, and 99s. per ton appears to be a minimum figure. No. 1 is at a premium of 6d. to 1s. per ton. In West Cumberland and North Lancashire hematite prices have developed a weaker tendency, Bessemer mixed numbers being quoted at 110s. to 115s. per ton delivered at Glasgow and Sheffield, and 117s. 6d. to 120s. delivered at Birmingham. Low-phosphorus iron likewise is in diminished demand.

MANCHESTER.—Movements in the local market for pig-iron may be again reported inactive, consumption for foundry purposes being still limited in extent by a shortage of orders in that industry, with buying restricted to the barest requirements. Makers of Derbyshire qualities of iron maintain a firm front as regards values, the current quotations remaining at 103s. delivered for No. 3 foundry pig. In the meantime it is understood that stocks at ironfounders' works must be practically exhausted, and as prices of pig-iron are now admittedly at the lowest levels likely to be accepted by makers, it is regarded as probable that more active business may be expected as the quarter advances.

THE MIDLANDS.—The increased activity in demand for foundry iron recently reported continues unchecked, and there has been a considerable amount of business done for forward delivery. Many merchants have taken this opportunity of buying ahead, and now the large consumers are entering the market. For the time being this has stopped any price-cutting; in fact, the reverse is the case, as the ruling quotations given below are very firm. Prices are as under: Derbyshire No. 3 foundry, 95s.; Staffordshire No. 3 foundry, 95s.; Northants No. 3 foundry, 92s. 6d.

SCOTLAND.—In this area of production there has been an increase in inquiries both for the home market and for abroad, and, in the former case, there is a distinct tendency to inquire for delivery over a period of several months. No. 3 Scotch foundry is quoted at 100s. per ton, f.o.t. furnaces. The Falkirk founders have been inquiring a little more freely, and No. 3 Middlesbrough is quoted at 97s. per ton, f.o.t. Grahamstown, with No. 4 foundry at 1s. per ton less.

Finished Iron.

Manufacturers of this class of material having been favoured by the placing of additional extensive contracts with railway wagon orders are in a much more satisfactory position, and consequently mills turning out the better qualities of iron bars are well employed. There is also a better demand for crown quality of iron, with prices firm at recent quotations. Makers of the nut and bolt iron also continue to receive more tonnage for this quality because of the extended delivery required by Continental producers, and by the fact that the supplies against old orders placed abroad are coming through very spasmodically. There is, however, still a marked difference between the foreign bolt iron and the local price.

Steel.

Although the outlook in the steel industry has been somewhat improved by the appreciation of the French and Belgian exchanges, business in the home markets has not yet been favourably affected, the threatening attitude of current labour troubles being discouraging factors in the position. In the market for semi-products, orders for basic billets, even soft qualities, have fallen off very badly, and acid billets, although taken in fairly substantial quantities, are not selling with anything like the freedom of a couple of months ago. There is, however, an improving demand for acid steel, sufficient, indeed, to warrant the putting into commission of a few more furnaces, but business in basic steel has fallen away. The demand for ferro-manganese has not been very large during the last week, and only small parcels have changed hands at the same price as last quoted. There has not been a great deal of actual business done in tinplates during the past week. The unsettled state of the tin market probably accounts for this to some extent, as there was a fair inquiry; buyers seem inclined to hold off as much as possible; 24s. 9d. per box was paid, but 24s. 7½d. was also accepted, and some second-hand parcels were done at 24s. 6d.

Scrap.

Reports from the various centres of scrap metal consumption show continued poor demand for all foundry purposes with current quotations mostly inclined to an easier tendency. No change has however, been made in Lancashire in the selling prices. Parcels of ordinary good quality cast scrap can be bought at 87s. 6d. per ton, and for special lots, such as broken textile machinery metal, from 90s. to 92s. 6d. per ton delivered is asked as contrasted with 102s. 6d. for No. 3 pig-iron, but the latter is very weak at the price, and ironfounders here seem confident that they will be able soon to buy on better terms. Steelworks are very short of orders, and it is feared that more will soon be closed down, thus further limiting the market for scrap. At Middlesbrough, heavy cast-iron scrap (machining quality) is down to 87s. 6d. to 90s., with ordinary qualities about 85s. Steel turnings and borings are better at 72s. 6d. and 70s. respectively. All these prices include delivery at works.

Metals.

Copper.—Although to some extent recovered from the reaction of last week, the position in the market for standard copper is still affected by the collapse of the recent speculative movements on the Continent, and the position in consequence disclosed a more irregular tendency. Trade prospects across the Atlantic, however, appear to be quite good and improving in the European trade. Requirements for electrical purposes are certainly on an enlarged scale, and a heavy outlet is well assured in that direction while extensive schemes of railway electrification are in the course of execution on either side of the Atlantic. American consumers, however, are fairly well covered for the present. Manufactured copper was quieter in the market, but quotations have been about sustained, despite the recent weakness. Current quotations:—*Cash*: Thursday, £64 2s. 6d.; Friday, £64 5s.; Monday, £64 5s.; Tuesday, £65; Wednesday, £65 7s. 6d. *Three Months*: Thursday, £65 2s. 6d.; Friday, £65 2s. 6d.; Monday, £65 2s. 6d.; Tuesday, £65 17s. 6d.; Wednesday, £66 5s.

Tin.—Movements in this section of the metals markets during the past week were sensational in character, values being forced down by speculative agencies pressing liquidation involving a decline of £18 in one day's transactions. There has not been much alteration in regard to the statistical position, speaking generally, although there has been some further increase in the home warehouse stocks, which, according to the weekly returns, amounted to 3,185 tons. Straits tin on this side remains in limited supply, and the fact has to be noted that amid the the recent great collapse very little cash tin actually came on the market. The Straits shipments for the first half of the month amounted to about 4,100 tons, and the estimates for the whole range from about 5,500 to 6,000 tons. Consumers who lately bought but little have come along again for fair quantities. American deliveries for this month are expected to be

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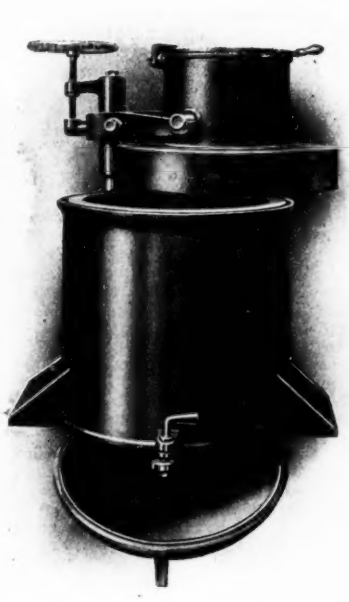

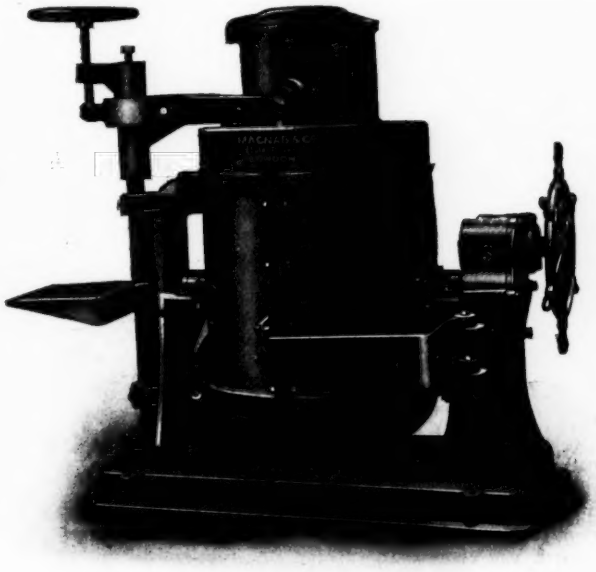

Tylor Patent Pit-Type Furnace.

OUTPUT.
200 lbs. Admiralty Gunmetal melted in 35 minutes. Temperature 2000° F.=1093° C.

ECONOMY.
25 lbs. of Coke used per 200 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 35 to 40 heats.

Tylor Patent Tilting-Type Furnace.

OUTPUT.
450 lbs. Admiralty Gunmetal melted in 50 minutes. Temperature 2000° F.=1093° C.

ECONOMY.
80 lbs. of Coke used per 450 lbs. of Metal melted.

STANDARD CRUCIBLES.
Lasting 30 to 40 heats.

56/8, EAGLE STREET, SOUTHAMPTON ROW, LONDON, W.C.1.

Works: TOTTENHAM, LONDON, N.17.

fairly heavy. Current quotations :—*Cash:* Thursday, £256; Friday, £261 15s.; Monday, £254; Tuesday, £257 10s.; Wednesday, £261 10s. *Three Months*: Thursday, £255 5s.; Friday, £260 15s.; Monday, £253; Tuesday, £256 10s.; Wednesday, £261 15s.

Spelter.—In common with other sections of the metals markets, lower values have also been recorded in the case of spelter, buying on consumptive account having slackened off, while America has also been selling on a freer scale than of late. Current quotations: *Ordinary:* Thursday, £34 2s. 6d.; Friday, £33 17s. 6d.; Monday, £33 10s.; Tuesday, £33 3s. 9d.; Wednesday, £33 12s. 6d.

Lead.—The market for soft foreign pig has also been subject to pronounced fluctuations in values, closing with a slightly weaker tendency. The recent sensational break was very sudden and precipitated by a great wave of selling in all metals, while Continental liquidation, largely on German account, played an important part in the unsettled state of the market. Current quotations: *Soft foreign (prompt)*: Thursday, £35 5s.; Friday, £35 10s.; Monday, £35 5s.; Tuesday, £34 7s. 6d.; Wednesday, £34 7s. 6d.

Company News.

Henry Berry & Company, Limited.—No interim dividend to be paid.

Butterley Company, Limited.—Interim dividend, 4d. per share, tax free.

Thomas W. Ward, Limited.—Interim ordinary dividend, 3¾ per cent., tax free.

A. C. Hodson, Limited, 30, Spring Gardens, Manchester.—Capital £3,000 in £1 shares. Engineers.

Mirrlees Watson Company, Limited.—Profit, £15,601; brought forward, £4,086; available, £19,687; dividend, 10 per cent., less tax, £14,404; carried forward, £5,283.

Cope, Allman & Company, Limited.—Trading profit, £5,236; income-tax reserve, £2,730; brought forward, £4,492; dividend, 10 per cent. on ordinary; carry forward, £4,077.

Sir W. G. Armstrong, Whitworth & Company, Limited.—Final dividend on ordinary shares, 6d. per share (or 2½ per cent.), making 1s. per share (5 per cent.) for year, less tax.

Isaac Swain & Nephew, Limited, Glasshouse Street, Salford.—Capital £8,000 in £1 shares (2,500 6 per cent. cumulative preference). Brass founders and finishers, etc. Permanent directors: C. Swain, sen., and H. Swain.

Adams & Gibbon, Limited, 2a, St. Thomas Street, Newcastle.—Capital £8,000 in £1 shares (2,000 7½ per cent. cumulative preference and 6,000 ordinary). Engineers, etc. Directors: A. A. Adams and L. H. Gibbon.

Ponsfords Technical Bureau, Limited, 202, Abbey House, Victoria Street, London, S.W.1.—Capital, £2,000 in £1 shares. Engineers, metal merchants, brokers, and agents. Directors: G. L. Ponsford and F. Williams.

Heap & Partners, Limited, 9, Albert Square, Manchester.—Capital £4,000 in £1 shares. Engineers, manufacturers' agents, consulting engineers, etc. Directors: J. D. Crichton, A. H. Atkins, E. E. Baker, and O. L. Spedding.

Bell's United Asbestos Company, Limited.—Balance dividend, 1s. 6d. per ordinary share, making 10 per cent. for year; reserve for depreciation and contingencies, £10,000, increasing that fund to £38,000; carried forward, £31,483.

C. & W. Walker, Limited.—Profit, £24,301; balance brought forward, £21,698; dividend, 10 per cent. per annum, free of tax, on ordinary, making 10 per cent. for year; bonus, 1s. per share, free of tax; reserve fund, £5,000; carry forward, £25,504.

Kloenkast, Limited.—Capital £2,000 in £1 shares, to acquire the business carried on at the Kloenkast Aluminium Foundry at East Sheen, Surrey. Directors: A. K. Smee and D. B. Miller. Solicitor: Jays & Jones, 37, Norfolk Street, Strand, W.C.2.

Warrington, Lee & Company, Limited, 25, Ironmonger Lane, London, E.C.2.—Capital £10,000 in £1 shares (6,000 10 per cent. cumulative participating preferred). Ship breakers, etc. Directors: Frank Warrington and J. Lee. General manager: J. W. Hearder.

Parker, Winder & Achurch, Limited.—Profit, £4,034; brought forward, £6,190; interim dividend, 6 per cent. per annum on preference shares and 5 per cent. per annum on ordinary shares, less tax; further dividend on preference shares, 6 per cent. per annum, less tax; dividend on ordinary shares, 10 per cent. per annum (making 7½ per cent. for year), less tax; carry forward, £7,013.

Stewarts & Lloyds, Limited.—Net profit, £459,426; depreciation, £90,000; brought in, £150,132; preference dividend, 6 per cent., less tax, for year; reserve, £50,000; employés' benefit reserve, £10,000; further dividend, 10 per cent. per annum on preferred ordinary shares, making 10 per cent. for year, less tax; dividend 2s. per share on deferred shares, plus bonus 6d. per share, both free of tax; carry forward, £101,795.

Gibbons (Dudley), Limited.—At the annual meeting in Birmingham, last week, Mr. W. P. Gibbons, the chairman, in mentioning that a not very large sum had been put to the hidden reserve, said there had been a great deal of correspondence in the papers lately as to the advisability or otherwise of hidden reserves. In times like the present, with labour difficulties and unrest, it was absolutely essential to have such a fund. In 1921, as a result of the coal strike, they lost £9,000, a loss which could not have been foreseen, but had it not been for the contingency fund they would drop an entire dividend in a year like that. The essential change that was coming in their business was the increased use of silica as against fire-brick, as he had known it all his business life. They had an unlimited supply and were extending their works.

Scottish Iron & Steel Company, Limited.—At the annual meeting in Glasgow, on March 21, Mr. William Downs, the chairman, in moving the adoption of the report, said that notwithstanding the gradual increase in output during the last three years, leading them to hope that the improvement meant a steady though somewhat slow return to a more normal state of affairs, the profits had not kept pace with the output. Of course, if something approaching full time employment could be attained costs would in the natural order of things be lower. In the iron trade they had not had a strike during the last forty years, but unfortunately in allied and kindred trades there had recently been strikes and stoppages of work, and still more were threatened. Although the output last year was greater than in 1922, the profit was almost £9,000 less, and that notwithstanding the fact that the £52,354 included a profit on the sale of part of their investments. The proceeds of that sale had been reinvested in a way that not only gave a good return, but conserved and safeguarded the capital. Considering the difficult conditions of trade during last year, the shareholders would no doubt agree that they had done very well indeed. They were also in the comfortable position of having definitely fixed and actually paid all their liability to the Government in respect of Munitions Levy and Excess Profits Duty. Last year they paid off £29,632 of debenture stock, and now only £97,845 remained outstanding. By the provision they were required to make annually for the redemption of debentures they would be entirely cleared off in another four years. Their works were in a high state of efficiency, and they were well equipped for dealing with any gradual or sudden development in trade.

British Metal Corporation, Limited.—The annual meeting was held recently at the registered office of the company, 3, Abchurch Yard, London, E.C. Mr. Charles Vincent Sale, chairman of the company, presided. In moving the adoption of the report, the chairman said: Last year I gave you some figures concerning the production and consumption of copper, lead, tin and spelter. The post-war recovery, which those figures were intended to illustrate has continued during 1923, and, although the complete statistics for that year are not yet available, we have prepared estimates which may be taken as reasonably near to the facts. Taking 100 as the annual average of the world's production in the three years 1911 to 1913, the figures for 1921, 1922 and 1923 are approximately:—1921: Copper, 57; lead, 74; tin, 85; spelter, 46. 1922: Copper, 91; lead, 93; tin, 102; spelter, 73. 1923 (estimate): Copper, 123; lead, 101; tin, 100; spelter, 100. Treating 100 as the annual average of the world's consumption in the three years 1911 to 1913, the figures for 1921, 1922 and 1923 are about:—1921: Copper, 59; lead, 70; tin, 66; spelter, 47. 1922: Copper, 96; lead, 90; tin, 104; spelter, 79. 1923 (estimated): Copper, 115; lead, 101; tin, 109; spelter, 95. You will notice the uninterrupted movement towards a volume of both production and consumption which, with one exception, now surpasses the pre-war standard. Opinions may differ concerning the benefit which mankind derives from the use of the motor-car and of wireless apparatus, but the increasing consumption of lead during recent years in the manufacture of these articles of comparative luxury is an important element in the present market position. Opinions may also differ concerning the virtue of preserved food, but under modern conditions the tin can continues to extend its dominion. The result is that in the case of both lead and tin demand is overtaking supply, and there are no signs of any early change in this state of affairs.

A receiving order has been made in connection with the affairs of Mr. A. J. McConnell, carrying on business at 65, Victoria Street, Westminster, S.W., metal merchant.